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Predictors of activity levels in patients with congestive heart failure

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# Predictors of Activity Levels in Patients with Congestive Heart Failure

by

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To Mom and Dad:

for teaching me perseverance, for allowing autonomy and most of all for giving me the opportunities that they themselves were never privileged enough to enjoy.

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# ABSTRACT

The purpose of this study was to determine psychologic and physiologic predictors of physical activity levels of patients with congestive heart failure. Specific variables examined included: anaerobic threshold, a measure of submaximal exercise; maximal oxygen uptake, a measure of maximal exercise; self-efficacy expectation for walking, general activity, and health maintenance to determine perceptions of capabilities of physical activity; and perceived exertion during Vitalog monitored physical activity, submaximal and maximal exercise. Subjects performed a symptom-limited exercise test with respiratory gas analysis and wore a Vitalog monitor no sooner than 24 hours after the completion of, or prior to, the exercise test. Subjects also kept a log of the most strenuous physical activity they performed while wearing the Vitalog monitor, including the type, duration, perceived exertion and symptoms experienced during the activity. Subjects also completed the Jenkins self-efficacy expectation scales and activity checklists prior to the exercise test.

The study sample consisted of 47 subjects mostly males (83%), with a mean age of 60, with various etiologies of congestive heart failure. The functional capacity of this sample was low as was self-efficacy. The relationship between self-efficacy for walking and exercise capacity was .32 to .35. A moderate, inverse

relationship was demonstrated between self-efficacy for walking (r=-.33, p=.02) and general activity (r=-.35, p=.02) and self-reported activity for walking (r=-.33, p=.02) and New York Heart Association functional classification. Although activity levels were low, most subjects reported no symptoms during physical activity (49%). Others reported dyspnea (21%), fatigue (15%) and sore muscles/joints (15%). When the percentage of agreement between the primary limiting symptoms were compared during exercise testing and Vitalog monitored physical activity, the two most common symptoms reported were fatigue (42%) followed by dyspnea (40%). Those who did not report symptoms considered the physical activity to be less strenuous than those who experienced symptoms. The selected variables were not found to be predictive of Vitalog monitored physical activity which may reflect the problems related to the instrument used to monitor physical activity or because of the particular combination of variables selected for this study.

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# Chapter One

# THE PROBLEM

Congestive heart failure (CHF) is a chronic, debilitating illness that affects three million Americans (Parmley, 1989). The most common cause of CHF is coronary artery disease (CAD) resulting in myocardial infarction (MI). Other less common etiologies of CHF include hypertension, congenital heart disease and cardiomyopathies. Regardless of the etiology, individuals with CHF frequently experience symptoms of fatigue and dyspnea. The characteristic functional limitations of CHF occur when these symptoms are precipitated by exertion; that, in turn, interferes with the individual's performance of physical activity.

The progression of CHF is assessed by the level of physical activity that elicits symptoms. As the severity of CHF increases, the level of physical activity the individual is capable of performing decreases. Initially, the individual with CHF may not experience any limitation in his/her physical activities. As CHF progresses, the performance of ordinary physical activity such as walking on level ground becomes more difficult. Eventually the individual may experience symptoms at rest. However, limitations in physical activity due to symptoms are highly variable among individuals with equivalent left ventricular (LV) ejection fractions. Thus the degree of physical limitation and the factors that influence it cannot be accurately predicted for any individual with congestive heart failure based on left ventricular ejection fraction.

The actual activity levels of individuals with CHF are difficult to determine and research in this area is limited. To date there are no studies that describe or identify those variables that affect activity levels of patients with congestive heart failure. Early research examined various methods of evaluating disease severity and found a poor correlation between clinical and hemodynamic evaluation and exercise performance (Franciosa, Ziesche, & Wilen, 1979; Patterson, Naughton, Pietras, & Gunnar 1972). This suggests that the clinical evaluation and the exercise test used to assess activity levels of patients with CHF requires further evaluation; an alternative method of assessment of physical activity may be necessary. Later studies examined the use of various physiologic measures such as norepinephrine levels (Francis, Goldsmith, & Cohn, 1982), maximal oxygen uptake (Dunselman et al., 1988; Itoh, Taniguchi, & Doi, 1990; Lipkin, Perrins, Poole-Wilson, 1982; Weber, Kinasewitz, Janicki, & Fishman, 1982; Wilson, Ferraro, Dunkman, & Jones, 1986) and anaerobic threshold (Lipkin, Bayliss, & Poole-Wilson, 1985; Opaisch et al., 1988) during exercise testing to determine functional capacity.

## Problem Statement

The aim of this study was to determine psychologic and physiologic predictors of activity levels in individuals with congestive heart failure. The variables of interest were: 1) anaerobic threshold (AT), 2) maximum oxygen uptake (max$\dot{V}O_2$), 3) ratings of perceived exertion (RPE) at AT and max$\dot{V}O_2$, and during physical activity and 4) perceived self-efficacy for general activity, walking and health maintenance.

## Purpose

The treatment of CHF is palliative, focusing on reducing symptoms through pharmacologic intervention. Little emphasis has been placed upon the impact CHF has on the individual or on other clinical therapeutics that may improve a patient's activity level. Although the focus of therapy is to reduce symptoms and thereby improve activity level, the understanding of the physiologic and psychologic factor/s that influence physical activity is limited. To date, there are few studies that examine the activity level of individuals with congestive heart failure or perceptions of capabilities for undertaking activity. The goal of this study was to determine those factor/s which may have an impact upon the levels of physical activity individuals with CHF are capable of performing. Identifying critical variables will assist in developing a more appropriate assessment of the severity of congestive heart failure. In addition, supplemental therapeutic strategies (such as cardiac rehabilitation and exercise training) can be developed and studied.

## Significance

Congestive heart failure (CHF) is a common clinical syndrome that affects approximately three million Americans or 1% of the population (Parmley, 1989). It is estimated that 400,000 individuals develop CHF each year (Collins, 1986). The incidence of CHF parallels that of coronary artery disease, rising sharply with advancing age with the highest incidence occurring after age 75 (Kannel, 1989). Between the ages 35-64, the annual incidence is 3 per 1000. The incidence climbs to 10 per 1000 between the ages of 64-94 (Kannel, 1989). Although the prevalence of CHF is greater in men than women age 65 or less, the reverse is true after the age of 75. Congestive heart failure is currently the most common hospital discharge diagnosis of individuals over 65 years of age (Parmley, 1989).

Once the symptoms of CHF are exhibited, prognosis is poor (McKee, Castelli, McNamara, & Kannel, 1971). Mortality is greater than 50% after 5 years with symptoms, and increases to 80% at 10 years (McKee, Castelli, McNamara, & Kannel, 1971). The 5 year mortality in males is approximately 60%, while in females it is 45%. The reason for this difference is unknown. It is believed that once symptoms of CHF occur at rest (New York Heart Association Functional Class IV), the mortality rate is approximately 50% within 10 years of onset (Franciosa, 1986; 1987). The most common cause of mortality is sudden death (Kannel, 1989).

The recurrence of symptoms, in addition to the considerable mortality rate, is commonly experienced by individuals with congestive heart failure. Within 6 years of onset, 63% of women and 70% of men had more than one episode of congestive heart failure. Individuals with CHF also were found to have a four-fold increased risk of stroke and 2 to 5 times increased risk of myocardial infarction (MI) when compared with healthy individuals (Kannel, 1989). Although these acute exacerbations of CHF are treated pharmacologically, individuals continue to experience fatigue, dyspnea or both sensations.

It can be concluded that CHF is a chronic, progressive illness in which the individual suffers acute exacerbations of symptoms. These symptoms ultimately limit an individual's physical activity and are controlled via pharmacologic intervention. Thus, it is not surprising that research addressing CHF primarily has been directed toward pharmacologic treatment. Early research studies focused on predicting exercise capacity in individuals with left ventricular dysfunction utilizing resting hemodynamic values such as LV ejection fraction and cardiac output (Engler et al., 1982; Franciosa, Ziesche, & Wilen, 1979; Patterson, Naughton, Pietras, & Gunnar, 1972). It was believed that patients with low LV ejection fractions would have a reduced exercise capacity; therefore, resting left ventricular ejection fraction could be used to predict activity levels of patients with left ventricular dysfunction. However, these studies failed to demonstrate a strong relationship between resting hemodynamic values and exercise capacity, as exercise capacity varied among patients with the same level of left ventricular dysfunction. Therefore, it was concluded that resting left ventricular ejection fraction did not correlate with activity levels of patients with congestive heart failure. It was speculated that other adaptive physiologic mechanisms contributed to the greater exercise capacity observed in these individuals.

Because the central contribution (cardiac output) was limited during exercise, the peripheral contributions to exercise capacity in patients with congestive heart failure presented an attractive alternative hypothesis to explain this disparity. The improvement in exercise capacity in patients with CHF after exercise training was believed to be a result of peripheral adaptations which included more efficient utilization of substrates and improved blood flow to active skeletal muscle (Sullivan, Higginbotham, & Cobb, 1988).

Recent studies have focused upon pharmacologic trials, description of exercise response (Conn, Williams, & Wallace, 1982) and the effectiveness of cardiac rehabilitation for patients with depressed LV function (Squires, Lavie, Brandt, Gau, & Bailey, 1987). These studies examined the effect of various interventions on exercise capacity as determined by maximal exercise testing. To date, there are few studies that focused on the activity level of patients with congestive heart failure as the relevant variable. Although the primary objective of therapy in patients with CHF is to improve activity levels, this phenomenon has not been fully described or studied.

To summarize, CHF is an unrelenting and debilitating illness with a poor prognosis. Research has focused primarily upon the pharmacologic management of patients with congestive heart failure and their exercise response. Research documenting the activity levels of patients with CHF is inadequate. The proposed study was designed to provide a better understanding of: 1) the level of physical activity patients with CHF are capable of performing and; 2) the factors which contribute to and predict the activity level of patients with congestive heart failure.

## Research Questions

The specific research questions addressed in this study were:

1. Is there a difference between ratings of perceived exertion (RPE) of the most strenuous activity performed and RPE at submaximal and maximal exercise in individuals with congestive heart failure?
2. Is there a difference between the limiting symptom experienced during the most strenuous activity and that experienced during the exercise treadmill test in individuals with congestive heart failure?
3. Is submaximal exercise a better indicator of activity level in the patients with CHF than maximal exercise?

4. What is the relationship between perceived efficacy for walking, general activity, health maintenance and exercise capacity in individuals with congestive heart failure?

5. What factor/s best predict activity levels in patients with congestive heart failure?

The goal of this study was to determine those factors which may have had an affect on or are predictive of the level of physical activity individuals with congestive heart failure are capable of performing. The impact of both physiologic and psychologic variables on physical activity were examined.

# Chapter 2

# THEORETICAL FRAMEWORK

The purpose of this chapter is to describe the theoretical foundations of this study. The complex pathophysiologic mechanisms that contribute to congestive heart failure (CHF) first will be described. The cardiovascular response to exercise in individuals with CHF then will be presented, including the methods used for exercise testing. This sets the stage for the review of literature addressing functional assessment of individuals with congestive heart failure. Self-efficacy also will be presented as relevant to individuals with congestive heart failure. Finally the conceptual model for this study will be presented.

## Pathophysiology of Congestive Heart Failure

### Definition

Congestive heart failure has traditionally been defined as the inability of the heart to deliver an adequate blood supply to peripheral tissues to meet metabolic demands (Parmley, 1989). This definition does not fully address the syndrome encountered in clinical practice which includes dyspnea (especially on exertion) as well as fatigue (Parmley, 1989). This traditional definition does describe the decrease in cardiac output that is believed to be the primary stimulus for fatigue, but does not adequately address the increased left atrial pressure believed to be responsible for dyspnea. Therefore, a more clinically useful definition of congestive heart failure, is the impaired cardiac output which leads to fatigue and the rise in left atrial pressure associated with dyspnea. Congestive heart failure is a clinical syndrome that consists of dyspnea (especially on exertion), elevated venous pressure, salt and water retention, and pulmonary congestion. Congestive heart failure is most commonly due to impaired myocardial function, but it is a broader entity that can include states in which the clinical syndrome is present but myocardial function is normal (Braunwald, 1984; Jennings & Esler, 1990).

## Etiology

In the past, the most common etiology of CHF was hypertension (Kannel et al., 1972). However, hypertension is no longer an important contributing factor to the development of CHF due to its better recognition and early treatment. Currently, the leading cause of CHF is coronary artery disease (CAD) resulting in myocardial infarction and left ventricular dysfunction (Franciosa, Wilen, Ziesche, & Cohn, 1983). The second most common cause of CHF is cardiomyopathy, an intrinsic disorder of the myocardium. Another common, although diminishing cause of CHF is rheumatic heart disease. Valvular heart disease due to mitral regurgitation or aortic stenosis also may cause congestive heart failure. Congenital heart disease is declining as a contributing factor to CHF due to better surgical repair of congenital lesions (Parmley, 1989).

Other infrequent etiologies such as hyperthyroidism, anemia, arteriovenous shunting or increased regional blood flow are associated with congestive heart failure. These disorders manifest themselves by increasing cardiac output causing a "high output state". Increased cardiac output causes increased demand on the heart that contributes to other factors that eventually lead to congestive heart failure. These high output states are relatively uncommon, although in patients with limited ventricular reserve any factor that increases the cardiac output can manifest itself in congestive heart failure (Parmley, 1989).

## Pathophysiology

In general, the disorders that cause congestive heart failure can be classified as systolic or diastolic dysfunction. Diastolic dysfunction is less commonly associated with CHF and is a result of any process which impedes ventricular filling. Disorders that cause diastolic dysfunction include hypertrophic cardiomyopathy, restrictive cardiomyopathy, pericardial disease and some infiltrative disorders such as amyloidosis.

The most common cause of congestive heart failure is systolic dysfunction as evidenced by a diminished ejection fraction. Decreased myocardial contractility is the primary disturbance in systolic dysfunction and can be a result of prolonged volume or pressure overload as well as an intrinsic decrease in the myocardial function per se as occurs in cardiomyopathy (Parmley, 1989).

There are four mechanisms which compensate for alterations of the cardiovascular system that occur as a result of congestive heart failure. These consist of changes in preload, afterload, heart rate and contractility. Although these compensatory changes serve to return the cardiovascular system, especially cardiac ouput, back toward normal, they may overshoot and contribute to worsening of CHF and increasing symptoms of fatigue and dyspnea (Parmley, 1989).

Congestive heart failure is a clinical syndrome, the earliest symptom of which is exercise intolerance due to fatigue or dyspnea on exertion. Other clinical signs include increased cardiothoracic ratio, peripheral edema, pulmonary rales, jugular venous distention and third heart sound (S3). These signs and symptoms manifest themselves because of inadequate or overcompensation by the normal physiologic mechanisms. Because CHF is most frequently a result of ventricular systolic impairment, one suspects that the response to exercise in these individuals will be compromised.

## Cardiovascular Response to Exercise in Patients with CHF

The cardiovascular (CV) response to exercise is complex and involves physiological changes that occur both in response to acute bouts of exercise and over a period of time with exercise training. The primary objective of the CV system is to deliver oxygen and substrates to the exercising muscle and promote efficient fuel utilization in order to perform physical work. For this to occur, there must be adequate coupling of various processes such as ventilation, circulation and cellular respiration. The interplay of these intricate systems determines the efficiency of the individual to respond to the physiologic stressor, exercise (see Figure 1).

Ventilation ←——→ Circulation ←——→ Skeletal Muscle
Cellular Respiration

Figure 1. Schematic illustration of coupling of external to internal ventilation.

The cardiovascular response to exercise in patients with CHF is different from that of the healthy individual. In individuals with CHF, central and peripheral compensatory mechanisms respond to maintain left ventricular function. It is the effectiveness of these mechanisms that determines the individuals' ability to exercise. In healthy individuals, exercise performance is dependent on greater cardiac output in response to increasing exercise levels. Many individuals with CHF have reduced left ventricular function both at rest and during exercise due to systolic dysfunction. Therefore, cardiac output fails to rise as exercise levels increase causing decreased blood flow to the periphery.

A reduction in circulatory blood flow due to reduced cardiac output activates the neurohumoral system causing vasoconstriction. However, this compensatory vasoconstriction causes increased afterload, and decreased stroke volume which effectively lowers cardiac output and increases myocardial oxygen consumption (Jennings & Esler, 1990).

The decrease in cardiac output to exercising skeletal muscle was believed to be the primary mechanism responsible for exercise intolerance due to fatigue (Francis, 1987; Letac, Cribier, & Desplanches, 1977). However, recent evidence demonstrates that in addition to abnormalities in skeletal muscle blood flow, biochemical alterations also may play a role in the sensation of fatigue.

Blood flow to the exercising skeletal muscle is diminished at rest and submaximal and maximal exercise compared with normals (Roubin et al., 1990; Sullivan, Knight, Higginbotham, & Cobb, 1989). The mechanism responsible for the diminished skeletal muscle blood flow is unclear, but data suggest that impairment of blood flow is not only a consequence of reduced cardiac output, but also may be a result of maldistribution of blood flow (Massie et. al., 1987; Weiner et al., 1986). In addition to changes in leg blood flow, leg vascular resistance is higher in patients with CHF than healthy individuals (Sullivan, Knight, Higginbotham, & Cobb, 1989).

Sullivan, Green, and Cobb (1990) suggest that alterations in the biochemical composition of skeletal muscle are responsible for muscle fatigue in patients with congestive heart failure. These investigators observed that in these subjects, oxidative enzyme activity was reduced, slow twitch (type I) fibers were decreased and fast twitch (type IIb) fibers were increased.

Lipkin, Jones, Round, and Poole-Wilson (1988) also studied muscle strength in the quadriceps muscle of 9 patients with severe chronic heart failure. A needle muscle biopsy was performed both at rest and during a treadmill exercise test. This group found biochemical and fiber type abnormalities in 8 of 9 subjects. This group of researchers found that there was increased acid phosphatase, interstitial cellularity, excess intracellular lipid accumulation and atrophy and hypertrophy of type I and type II muscle fibers, respectively. In addition to these changes in fiber types, variations in fiber size also were noted.

These 2 studies demonstrate that exercise intolerance due to fatigue in patients with CHF is not only a result of reduced blood flow to skeletal muscle but also is caused by biochemical and histologic changes. These abnormalities may be due to the decrease in blood flow to skeletal muscle or reduced cardiac output or in fact may be a genetic predisposition that is activated by CHF or merely a result of deconditioning. More studies in this area are needed to examine this question.

Historically, patients with congestive heart failure or left ventricular dysfunction have been omitted from exercise training programs. In the past, exercise training in patients with CHF was contraindicated due to concern that these patients were at high risk for developing life-threatening arrhythmias or precipitating decompensation of the left ventricle (Williams, 1985). Conn, Williams, and Wallace (1982) have demonstrated that exercise training in patients with CHF improves exercise capacity without significant exercise related morbidity or mortality.

After exercise training, there is a decrease in heart rate and blood pressure at rest and during submaximal exercise (Letac, Cribier, & Desplanches, 1977). However, at maximal exercise, heart rate is unchanged as compared to maximal heart rate before exercise training. In addition, an improvement in cardiac output during maximal exercise was observed in some individuals; however, this increase was not statistically significant (Sullivan, Higginbotham, & Cobb, 1988).

Sullivan, Higginbotham, and Cobb (1988) trained 12 patients with CHF and a left ventricular ejection fraction of less than 24% for 4 to 6 months by exercising 4.1 +/- 0.6 hours per week at a heart rate corresponding to 75% of peak oxygen consumption. These researchers concluded that despite a lack of improvement in cardiac output, exercise training in patients with chronic heart failure improved exercise capacity. This improvement was achieved primarily by peripheral adaptations to exercise training which include an increase in peak blood flow to exercising skeletal muscle. During submaximal exercise, arterial blood lactate levels were reduced without improvements in cardiac output. Therefore, in patients with chronic heart failure, peripheral adaptations involving utilization of substrates and oxygen, or oxygen transport were the factors responsible for delayed lactate production, delayed metabolic acidosis and improved exercise capacity (Hoffman, Duba, Lengyel, & Majer, 1987; Lee, Ice, Blessey, & Sanmarco, 1979; Letac, Cribier, & Desplanches, 1977; Sullivan, Higginbotham, & Cobb, 1988). Minotti et al. (1990) went on to demonstrate that improvements in oxidative capacity of skeletal muscle were observed in patients with congestive heart failure after exercise training independent of systemic or central adaptations. These changes in oxidative capacity may be the key mechanism for improved exercise capacity in patients with CHF, independent of the central mechanisms.

Based upon these studies, it is evident that patients with CHF can improve their exercise capacity with exercise training. However, the improvement in exercise capacity is largely a result of peripheral adaptations rather than changes in the central mechanisms.

## Methods of Assessing the Cardiovascular Response to Exercise

### Exercise Testing

Exercise testing is an objective method of evaluating disease severity (Franciosa, 1987) and is used to determine exercise capacity or the maximal amount of metabolic expenditure the individual is capable of during maximal effort exercise (American College of Sports Medicine, 1986). Specific variables such as electrocardiographic (EKG) changes, maximum oxygen uptake ($\dot{V}O_2max$), anaerobic threshold (AT), ratings of perceived exertion (RPE) and symptoms experienced during exercise are used to assess exercise capacity.

## Treadmill Exercise Testing

The treadmill is the most common mode of exercise testing because it is convenient and a familiar form of physical activity to most individuals (DeBusk, 1986; Hanson, 1988). Because it incorporates body weight and involves more muscle groups than bicycling, maximal oxygen consumption ($\dot{V}O_2$) is greater with treadmill exercise than bicycle ergometry. Treadmill exercise is reproducible because workload is easily regulated by speed and grade of the belt depending upon the protocol being used (Janicki & Weber, 1986).

## Standard Treadmill Protocols

Treadmill protocols usually begin with low workloads, that serve as a warm-up period that allow the subject to relax, become familiar with the apparatus and establish a comfortable gait and rhythm. Most protocols allow approximately 2-3 minutes per stage so that a steady state $\dot{V}O_2$ level can be attained (Hanson, 1988). The total time of the exercise test should not exceed 20 minutes. Beyond this time, other factors such as mouthpiece or noseclip discomfort, thirst, dry throat, or boredom may cause the subject to stop rather than reaching a maximal workload. In addition, exercise exceeding 20 minutes measures endurance which may not be the purpose of the test (Janicki & Weber, 1986; Pollock, Wilmore, & Fox, 1984).

Exercise testing protocols need to be appropriate to the exercise capability of the subject. If a subject is suspected of having poor exercise tolerance, a less strenuous exercise protocol needs to be selected, such as the Naughton. One disadvantage of the less strenuous protocols is that most subjects require a longer exercise time to accomplish the same end point, which may exceed 20 minutes (Janicki & Weber, 1986; Pollock et al., 1984).

### Maximal Oxygen Consumption ($\dot{V}O_2max$)

A method used to measure functional capacity of the cardiovascular system is maximal oxygen uptake ($\dot{V}O_2max$). It is the maximal rate at which oxygen ($O_2$) can be taken up, distributed and used by the body during exercise. Maximal oxygen uptake provides information concerning how well the heart is able to function under the stress of exercise (Holly, 1988). $\dot{V}O_2max$ is the greatest amount of oxygen that a person can extract from room air while performing maximal, dynamic exercise requiring a large part of the total muscle mass (Wasserman, Hansen, Sue, & Whipp, 1987). In normal subjects, $\dot{V}O_2max$ is characterized by a plateau of $O_2$ uptake ($\dot{V}O_2$), despite an increase in work rate (Froelicher, 1987). Maximum workrate continues to increase as a result of anaerobic metabolism which provides the energy necessary to continue exercise beyond $\dot{V}O_2max$ (Holly, 1988).

Wasserman and associates (1987) make a distinction between $VO_2max$ and maximum or peak $\dot{V}O_2$ (max$\dot{V}O_2$). The former is the true maximal level attained as demonstrated by a plateau of $\dot{V}O_2$ despite an increase in workrate. Maximum $\dot{V}O_2$ (max$\dot{V}O_2$) or peak $\dot{V}O_2$ is the highest $\dot{V}O_2$ achieved during symptom-limited exercise testing. During symptom-limited exercise testing, exercise is discontinued when the patient feels he/she is unable to exercise any longer. Consequently, a true $\dot{V}O_2$max or a plateau of $\dot{V}O_2$ is not necessarily observed. Maximum $\dot{V}O_2$ (max$\dot{V}O_2$) has been found to be useful in monitoring disease response to therapy (Weber, Janicki, & McElroy, 1986). One major weakness of both max$\dot{V}O_2$ and $\dot{V}O_2$max is the influence of subject motivation during exercise performance (Simonton, Higginbotham, & Cobb, 1988). Another weakness is the lack of similarity between exercise testing and daily activities, considered submaximal in nature (Franciosa, 1987; Neill et al., 1985). To remedy this weakness, submaximal exercise testing is recommended as an alternative for determining activity level because it more closely resembles daily activity levels (Franciosa, 1987). However, the use of submaximal exercise testing requires further investigation.

Maximal oxygen uptake ($\dot{V}O_2$max) is expressed in liters/minute. Maximal oxygen uptake can be standardized to account for differences in body weight and is expressed as ml/kg/min. Standardization for body weight is important because individuals who weigh more generally have greater muscle mass and would therefore consume greater oxygen with exercise (Froelicher, 1987). The $\dot{V}O_2$max is affected by age, gender, body weight, physical conditioning, and disease. The $\dot{V}O_2$max of a normal sedentary male between the ages of 25 - 65 is approximately 40 ml/kg/min. A normal fit male is approximately 50 ml/kg/min. A trained male endurance athlete averages 60 - 75 ml/kg/min. There is a reported decrease of 5 ml/kg/min per decade between the ages 25 - 65 (Holly, 1988). In women from adolescence to

35 the average $\dot{V}O_2$max is between 40 - 45 ml/kg/min. After the age of 35, there is a steady decrease to 25 ml/kg/min at age 65 (Holly, 1988). After the age of 65, the $\dot{V}O_2$max decreases dramatically. There are two methods for determining $\dot{V}O_2$, the direct and the predicted.

## Direct Assessment of $\dot{V}O_2$

In order to determine $\dot{V}O_2$ using this method, subjects must undergo an exercise test most commonly treadmill or bicycle ergometry. During exercise, respiratory gas analysis is performed which requires the subject to wear a mask or a mouthpiece used for respiratory gas collection. (see Figure 2) (Holly, 1988; Janicki, Schroff, & Weber, 1986). There are three direct methods used to assess $\dot{V}O_2$: 1) the timed collection of expired air; 2) a mixing chamber method; and 3) the breath by breath analysis of respiratory gases. Breath by breath will be discussed as it is the method used in this study.

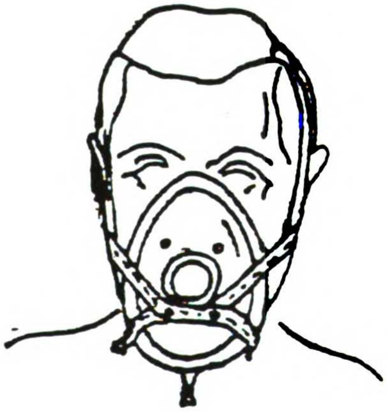

Figure 2. Face mask set up: Sensormedics Horizon 4400

<u>Breath by Breath Analysis</u>. The breath by breath analysis method used to assess $O_2$ uptake provides the most complete data of the gas exchange response during exercise. This method alleviates the concern about adequate gas mixture, by eliminating the mixing chamber with a sampling line which connects directly to the mouthpiece. Expired gas is removed from the nonrebreathing valve and delivered to $O_2$ and $CO_2$ analyzers which measures gas concentrations continuously (Janicki, Schroff, & Weber, 1986). More detail regarding the specific method of respiratory gas analysis used in this study will be provided in chapter three.

One of the issues concerning validity of the direct measure for $\dot{V}O_2$max is whether or not $\dot{V}O_2$max is actually achieved. Taylor, Buskirk, and Hencshel (1955) determined $\dot{V}O_2$max as a change in $\dot{V}O_2$ of less than or equal to 150 ml/min (2.1 ml/kg/min) with a corresponding increase in workload. Taylor et al. (1955) found that approximately 75% of his subjects achieved a plateau in oxygen uptake.

Weber, Kinasewitz, Janicki, and Fishman (1982) found maximum $\dot{V}O_2$ to be a valid measure of maximal oxygen consumption in patients with congestive heart failure. Subjects with CHF (n=40) were asked to exercise until severe fatigue or dyspnea made them unable to continue. The correlation between percent oxygen extraction and percent maximal oxygen consumption was .983. Although true $\dot{V}O_2$max was not attained, max$\dot{V}O_2$ was demonstrated as a valid measure of maximal oxygen consumption.

Validity of direct measurement methods can be improved by allowing subjects to become familiar with the equipment prior to the actual exercise testing so that anxiety will not affect the test results. Environmental factors should also are controlled, especially room temperature. In addition, the use of handrails is discouraged during exercise testing because it has been found to increase $\dot{V}O_2$max by as much as 30% (Ragg, Murray, Karbonit & Jump, 1980; Zeimitz, Moss, Butts, Wilson, & Obma, 1979).

Maximal oxygen uptake ($\dot{V}O_2$max) has been found by Bruce, Kusumi, and Hosmer (1973) to have a reliability of .990 in healthy, normal subjects (n=77) and .945 in patients (n=12) with clinically stable cardiac disease. Because attaining a true $\dot{V}O_2$max can be problematic in patients with CHF, max$\dot{V}O_2$ is usually measured during a symptom-limited exercise test. Because it is symptom-limited, reliability of max$\dot{V}O_2$ is of concern to clinicians. The reliability of max$\dot{V}O_2$ has been found in patients with CHF to range from .77 (n=47) when retested within 2 weeks, to .986 (n=43) when retested days to weeks apart (Kappler, Ziesche, Nelson, & Francis, 1986; Weber, Kinasewitz, Janicki, & Fishman, 1982). The reliability may be affected by the treadmill apparatus, primarily the calibration of height and speed of the belt, although most of the variation is not due to equipment but rather a learning effect of the individual performing the exercise (Holly, 1988).

## Anaerobic threshold

Anaerobic threshold is "the level of exercise $\dot{V}O_2$ above which aerobic energy production is supplemented by anaerobic metabolism and is reflected by an increase in lactate and lactate/pyruvate ratio in muscle or arterial blood" (Wasserman, Hansen, Sue, & Whipp, 1987 pp. 237). Anaerobic threshold as determined by respiratory gas exchange method is a noninvasive index of blood lactate accumulation during exercise (Wasserman, Hansen, Sue, & Whipp, 1987). During exercise in patients with CHF, muscle metabolism frequently becomes anaerobic generating lactic acid. Metabolic acidosis is a result of left ventricular (LV) dysfunction which impairs cardiac output (CO) and delivery of $O_2$ to exercising skeletal muscle. Lactic acid accumulation is buffered by bicarbonate which produces carbon dioxide ($CO_2$) in excess of the level that is normally generated from oxidative metabolism alone (see Figure 3). As $CO_2$ production increases, ventilation ($\dot{V}E$) must increase in order to eliminate the excess $CO_2$ produced. Therefore, ventilation increases proportionally with increased $CO_2$ production ($\dot{V}CO_2$). While there is an increase in $O_2$ uptake, it is less than that observed with ventilation and $CO_2$ production. When ventilation and $CO_2$ production increase proportionally with a slight increase in $O_2$ uptake this is known as isocapnic buffering. Isocapnic buffering lasts approximately 2 minutes and occurs in healthy individuals at approximately 60% to 70% $\dot{V}O_2$max and is also the point that is known as the anaerobic threshold (Lipkin, Bayliss, & Poole-Wilson 1985; Wasserman, Hansen, Sue, & Whipp 1987).

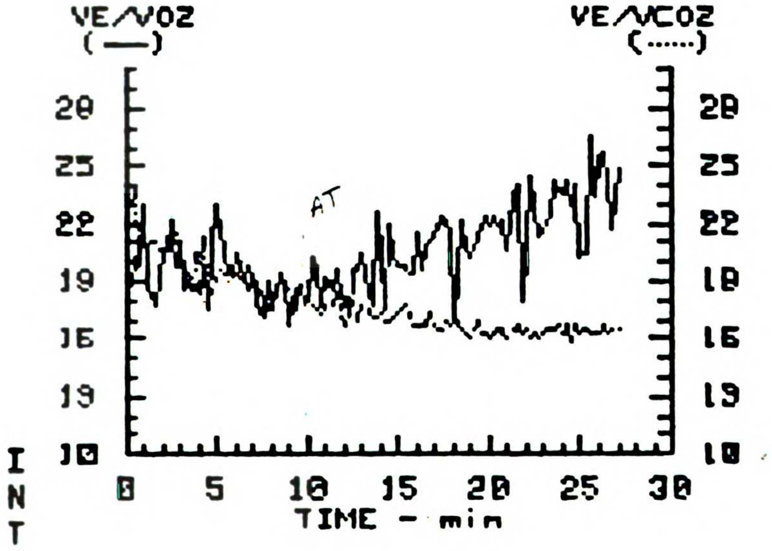

Figure 3. Determination of Anaerobic Threshold

Recent studies have demonstrated that maximal exercise capacity can be estimated from determination of anaerobic threshold, which is independent of subject motivation during an exercise test in both healthy individuals and those with cardiac disease (Lipkin, Bayliss, & Poole-Wilson, 1985; Matsumura et al., 1983). Because anaerobic threshold is determined at approximately 60%-70% of $\dot{V}O_2$max, it is considered submaximal exercise and does not require the intensity of exercise or the level of motivation necessary for a maximal exercise test, which can be extremely uncomfortable and difficult for an individual with chronic CHF to perform (Lipkin, Bayliss, & Poole-Wilson, 1985). Determination of anaerobic threshold appears to be a reasonable alternative to maximal exercise testing and can be used to assess severity of congestive heart failure. However, anaerobic threshold requires further evaluation using larger sample sizes. To date, no studies have been reported that examine the relationship between anaerobic threshold and level of physical activity.

The validity of anaerobic threshold by means of respiratory gas evaluation has been examined by two groups. These researchers compared the arterial lactate concentration with visual determination of anaerobic threshold. The correlation between arterial lactate concentration and anaerobic threshold in patients with CHF ranged from .93 (n=15) (Itoh, Koike, Taniguchi, & Marumo, 1989) to .962 (n=8 normals, 9 CHF patients) (Matsumura et al., 1983). However, one must be cautious of the small sample size, the different exercise protocols used in these 2 studies, and the severity of illness in the samples examined (Itoh, Koike, Taniguchi, & Marumo, 1989; Matsumura et al., 1983).

The reliability of anaerobic threshold in patients with CHF was also examined in these studies. Itoh and associates (1989) found that with a 3 hour interval between 2 exercise tests the correlation of anaerobic threshold was .89 (n=17). Simonton, Higginbotham, and Cobb (1988) found that with a 1 day interval between 2 exercise tests, the correlation was .914 (n=31).

### Ratings of Perceived Exertion (RPE)

The rating scale of perceived exertion, known as the Borg scale, is a measure of the overall integration of various physiologic and psychologic factors that have an impact on an individual's perception of exertion to a given task (Borg, 1982; Maresch & Noble, 1984). The RPE scale is used during exercise testing to provide information about an individual's own sense of effort in addition to objective information such as heart rate (HR) and oxygen uptake (Maresch & Noble, 1984).

The ratings scale used in this study ranged from 0 to 10 with simple verbal anchors which gave the expression a quantitative meaning or position on the scale. For example, 2 is described as weak, or light, therefore, 4 is twice the intensity of two (Borg, 1982).

Borg (1970) and Skinner and Hutsler, Bergsteinova, and Buskirk (1973) found the correlation between HR and RPE was 0.8 to 0.9 in young, healthy individuals during continuous exercise. Also in young, healthy subjects, RPE correlated with other physiologic variables such as oxygen uptake ($\dot{V}O_2$ ml/kg/ min) (r=.85), minute ventilation ($\dot{V}E$) (r=.84) (Skinner, Hutsler, Bergsteinova, & Buskirk, 1973) and workload (r=.933) (Ullmer, Janz, & Lollgen, 1977) during continuous exercise.

When patients with coronary insufficiency and arterial hypertension were studied by Borg and Linderholm (1970), RPE and HR were significantly higher in the patient group than in healthy subjects. Turkulin, Zamlic, and Pegan (1977) found that in patients post myocardial infarction (MI) the correlation coefficient between RPE and HR was 0.4 ($p < .01$) and for untrained healthy men r=0.589 ($p < .01$), and for sportsmen r=.692 ($p < .01$). Another study conducted by Borg and Linderholm (1967) found that age also altered the relationship between HR and RPE. In general, as age increased, the work resulting in a given HR was perceived as being more strenuous. In these studies, when RPE was determined for individuals in terms of absolute values of work ($\dot{V}O_2$max, or maximum HR), RPE scores differed. When RPE scores for individuals were compared to relative work levels (percent of $\dot{V}O_2$max or percent of maximal HR) RPE values were similar (Ekblom & Goldbarg, 1971; Skinner, Hustler, Bergsteinova, & Buskirk, 1973). The findings from these studies demonstrate that although RPE has a high correlation to HR in healthy individuals, the correlation decreases when applied to subjects with myocardial infarction, arterial hypertension and coronary insufficiency. Therefore, when the RPE scale is used with patients with coronary artery disease (CAD), the original concept of estimating HR from this scale is not valid. However, the use of the RPE scale in terms of rating the subjects level of exertion in relation to relative workloads is valid.

## Self-Efficacy

Self-efficacy (SE) theory is derived from social learning theory and is used to explain the integration of cognitive, social and behavioral skills which must be organized and integrated into a course of action. Successful action comes about when the individual tests various strategies and generates ones that are successful (Bandura, 1986). Perceived self-efficacy is defined as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performance" (Bandura, 1986 pp. 391). Self-efficacy does not necessarily pertain to the skills one has but rather the judgments regarding what a person can do with those skills.

There are two types of perceptions of one's capabilities, efficacy expectations and outcome expectations. Efficacy expectation involves the belief in one's ability to execute a behavior required to produce certain outcomes. Outcome expectation is the belief that a given behavior will result in a certain outcome (Bandura, 1977, 1986). While both types of efficacy are important, efficacy expectation is especially relevant in determining individual course of action in the cardiac patient.

There are 4 sources of information which contribute to an individual's efficacy. These are: 1) enactive attainment, mastery or performance of a task, 2) vicarious experience which involves the activity of others, 3) verbal persuasion or social persuasion which involves the influence of others, and 4) physiologic cues (Bandura, 1986; Gortner, Houston-Miller, & Jenkins, 1988).

Enactive attainment is based upon the individuals' actual mastery experiences and is the most powerful source of efficacy information (Bandura, 1986). The success and failures of an individuals' performance of a task is considered within the context of the experience. For example, if an individual has strong self-efficacy through repeated successes, occasional failures will not have a significant effect on the individuals' sense of self-efficacy. These individuals are more likely to attribute occasional failures to situational factors such as poor effort or strategies (Bandura, 1986).

Vicarious experience involves an individual's observation of other people or models performing activities successfully which leads the individual to feel that they too are capable of mastery of the activity (Bandura, 1986). In order for these models to be effective, the task must be achieved with some perceived effort rather than easily accomplished. It is also important that the model have similar characteristics such as age, sex, or clinical problem as that of the observer (Stretcher, DeVellis, Becker, & Rosenstock, 1986).

Verbal persuasion is the third source of efficacy information. It is commonly used to persuade people to believe that they possess the necessary capabilities to achieve their goal. This method may be somewhat limited in its ability to achieve a long term change in self-efficacy. However, realistic verbal persuasion can contribute to successful performance (Bandura, 1986).

Physiologic cues are the last source of self-efficacy information. Physiologic cues such as palpitations, nausea, and diaphoresis can be interpreted by the individual as vulnerability, and are detrimental to self-efficacy (Bandura, 1986).

Information that is received by these various sources (enactive, vicarious, verbal, and physiologic) must be processed in order to become meaningful. The cognitive appraisal of information involves weighing and interpretation of the situation.

How a situation is weighed by the individual can have a tremendous impact on self-efficacy. Most individuals accurately monitor both the positive and negative aspects of performance, but individuals tend to discount the relative importance of one aspect. For example, individuals with low self-esteem tend to discount positive efficacy information (Bandura, 1986; Stretcher, DeVellis, Becker, & Rosenstock, 1986).

Interpretation of an activity and how it relates to the individual's own attributes is an important mediator of self-efficacy information. The individual must believe that success is attributed to his/her own ability in order to foster positive self-efficacy. It is also important that success is achieved without a great deal of effort, otherwise self-efficacy is not enhanced (Bandura, 1986; Stretcher, DeVellis, Becker, & Rosenstock, 1986).

## Self-efficacy and Exercise

There are few studies which examine the relationship between self-efficacy and exercise. Ewart, Taylor, Reese, and DeBusk (1983) examined the effects of exercise testing 3 weeks post uncomplicated myocardial infarction on self-efficacy. The sample consisted of 40 men with a mean age of 52 +/- 9 years. This group examined the level of confidence these subjects had in their ability to perform various physical activities both before and after a treadmill exercise test. After the exercise test, subjects demonstrated increased confidence in their ability to perform activities which were similar to treadmill exercise such as walking, stair climbing and running. Improvement in dissimilar activities such as sexual intercourse and lifting did not increase until patients were counseled by a physician or nurse. This group also examined the effects of treadmill exercise on self-reported physical activity and found that changes in self-efficacy scores for leg work correlated ($r=.53$ and $.34$ $p < .01$) with self-reported mean heart rate and with average duration of self-reported leg exercise during home activity.

Taylor, Bandura, Ewart, Miller, and DeBusk (1985) examined the effect of spousal involvement during exercise testing 3 weeks after myocardial infarction. Wives were divided into 3 groups: 1) wives who did not observe the exercise test, 2) wives who did observe the exercise test, and 3) wives who observed and also walked on the treadmill at the maximal workload attained by their spouse. These researchers found that the wives' final rating of perceived efficacy in their husbands' physical and cardiac capabilities were higher if they performed the exercise test themselves.

These studies are only two of many which have examined self-efficacy in the cardiac population. Several investigators have examined self-efficacy in patients recovering from a cardiac event. To date, no studies have examined self-efficacy in patients with congestive heart failure and its relationship to physical activities.

## Functional Assessment of Patients with CHF

Symptoms of CHF in patients with left ventricular dysfunction occur when there is impairment to the left ventricle which reduces cardiac function. The earliest symptom of CHF is limitation of physical activity. Jennings and Esler (1990) define functional capacity as "the final result of the interaction between the effects of myocardial impairment and the opposing compensatory mechanisms" (pp. II-6). Assessment of functional capacity reflects the degree to which the body is effectively coping with impaired cardiac function. Functional assessment is performed either by the NYHA functional classification criteria or exercise testing.

## Historical Perspective

Franciosa, Ziesche, and Wilen (1979) examined the relationship between maximal functional capacity as determined by bicycle ergometry to clinical and hemodynamic characteristics of 44 class II to IV patients with ischemic or idiopathic cardiomyopathy. This group found the correlation between resting index and exercise performance was 0.30. Clinical classification by NYHA functional criteria agreed with exercise performance in 16 of 44 (36%) subjects. This study by Franciosa, Ziesche, and Wilen (1979) was important because it was the first to demonstrate the poor correlation between resting hemodynamic parameters specifically cardiac index with exercise capacity. This study lead researchers and clinicians to question the usefulness of left ventricular performance in assessing functional capacity.

A threat to internal validity of this study is instrumentation. Cardiac output was measured using respiratory gas analysis instead of thermodilution techniques which is the accepted gold standard. The reliability and validity of cardiac output determined by respiratory gas analysis is questionable and should have been addressed in greater detail.

Four other studies examined the relationship between exercise capacity and resting left ventricular function as measured by left ventricular ejection fraction (LVEF) (Benge, Litchfield, & Marcus, 1980; Engler et al., 1982; Hakki, Weinreich, DePace, & Iskandrian, 1984; Franciosa, Park, & Levine, 1981). All 4 studies found that resting measures of left ventricular function did not correlate with exercise capacity.

Benge, Litchfield, and Marcus (1980) studied 32 subjects ages 36 to 76, with left ventricular ejection fraction of less than 30% (by gated radionuclide testing) and on stable medication dosages. This group found that approximately 50% of subjects with low left ventricular ejection fraction exercised between 12 to 15 minutes on a treadmill.

One of the difficulties in evaluating these 4 studies is the use of different exercise testing methods. Exercise capacity was determined by bicycle ergometry in 1 study (Hakki, Weinreich, DePace, & Iskandrian, 1984) and treadmill exercise in 3 (Benge, Litchfield, & Marcus, 1980; Engler et al., 1982; Franciosa, Park, & Levine, 1981).

Although 3 of 4 studies used treadmill exercise testing, all 3 used different exercise protocols and reported exercise duration, not workload, making comparison of the results difficult. In order to compare these 4 studies, one must calculate the various workloads in each stage of exercise of the various protocols. Determination of maximum oxygen consumption would have helpful in these studies so that maximal $\dot{V}O_2$ values could have been compared.

In summary, these early studies found that measurement of resting left ventricular performance was not a valid means for clinical evaluation of patients with congestive heart failure. Therefore, researchers began to examine the exercise test as an alternative method to assess functional capacity.

## Measurement of Functional Capacity During Exercise

The exercise test is a method of assessing functional capacity by evaluating exercise capacity. Exercise capacity is the ability of the individual to perform exercise. Graded exercise testing provides direct information about the ability of the cardiovascular system to perform under stress and meet the challenge of increased oxygen demand (Jennings & Esler, 1990). The following studies address the use of physiologic variables measured during exercise testing to determine functional capacity in individuals with congestive heart failure.

Three studies examined the use of physiologic parameters norepinephrine (Francis, Goldsmith, & Cohn, 1982) and anaerobic threshold (Lipkin, Bayliss, & Poole-Wilson, 1985; Opaisch et al., 1988) to predict functional capacity in patients with congestive heart failure. Francis, Goldsmith, and Cohn (1982) examined 17 men with a mean age of 55, with class II to IV chronic congestive heart failure. All subjects had a clinical history of CHF of at least 6 months duration and were controlled on stable medication dosages.

This group found that 14 of 17 patients who underwent upright symptom limited treadmill exercise testing attained an average peak $\dot{V}O_2$ of 10.60 +/- 1.40 ml/kg/min. The correlation between peak $\dot{V}O_2$ with left ventricular ejection fraction was .36. When resting plasma norepinephrine was examined in relation to peak $\dot{V}O_2$ the correlation coefficient was -.50. This group concluded that resting left ventricular ejection fraction was a poor marker for assessing exercise capacity. However, resting plasma norepinephrine levels may be an appropriate alternative for predicting exercise capacity.

Other researchers have focused upon the use of submaximal exercise testing parameters such as anaerobic threshold to predict maximal exercise capacity. These researchers feel that using submaximal exercise parameters more accurately reflects functional ability because it resembles more closely the energy expenditure required during normal daily activities. Two studies examined the role of anaerobic threshold in predicting maximal exercise capacity.

Lipkin, Bayliss, and Poole-Wilson (1985) were interested in whether submaximal exercise testing using determination of anaerobic threshold was predictive of maximal oxygen consumption. This group studied 29 males with a mean age of 48 with class II or III congestive heart failure. All subjects performed a symptom limited treadmill exercise test with respiratory gas analysis.

This group found that anaerobic threshold correlated with $VO_2max$ ($r=.93$, $p <.0001$) in 29 subjects. Twenty three of 29 subjects exercised to a respiratory quotient of 1 indicating a near maximal or maximal effort. These investigators concluded that the measurement of submaximal exercise capacity as determined by anaerobic threshold can be used to assess maximal exercise capacity in patients with congestive heart failure.

Another study conducted by Opasich et al. (1988) examined whether anaerobic threshold could be used to assess left ventricular function during exercise. This group studied 20 male patients between the ages of 37 and 64 with class I to II chronic stable congestive heart failure. This group found that anaerobic threshold could be used to assess severity of left ventricular dysfunction. Subjects with low anaerobic threshold levels 8.6 +/- .7 ml/kg/min had abnormal exercise pulmonary capillary wedge pressure and low cardiac index. Those subjects with high anaerobic threshold levels 16.9 +/- .4 ml/kg/min showed no left ventricular impairment during exercise (wedge pressures were normal as were increases in cardiac index). This study was difficult to evaluate because description of methodology was sparse. In addition, correlation coefficients for relationships were not reported.

Gibbs et al. (1990) examined the pulmonary artery pressure changes which occur during daily activities in patients with chronic congestive heart failure. This group studied 7 men with a mean age of 55 with chronic CHF due to either ischemic heart disease (n=7) or dilated cardiomyopathy (n=2). All 7 subjects underwent 24 hours of ambulatory pulmonary artery pressure monitoring and an exercise treadmill test.

This group found that pulmonary artery pressure was increased in all subjects during exercise testing, and that there was a wide variation in pulmonary artery pressure before, and at peak exercise. Pulmonary artery pressure was highest walking up and down stairs versus walking on a flat surface. Another interesting result of this study was that the symptom of breathlessness did not correlate with increased pulmonary artery pressure or pulmonary artery pressure at maximal exercise.

Threats to internal validity of this study include patient selection which was a convenience sample and statistical conclusion validity. The sample size was small including only 7 subjects. One must also question construct validity in this study. The activities studied were position in bed, meals and urination. These activities do not reflect the realm of normal daily activities. It is unclear why these particular activities were chosen to be examined in this study.

Six studies examined the use of respiratory gas analysis in determining severity of congestive heart failure. All samples consisted of patients with congestive heart failure of various NYHA functional classification. Weber, Kinasewitz, Janicki, and Fishman (1982) had the most diverse sample including subjects from class I to IV. All subjects had a left ventricular ejection fraction of less than 40%. The sample sizes of the 6 studies ranged from n=22 (Wilson, Fink, Ferraro, Dunkman, & Jones, 1986) to n=72 (Itoh, Taniguchi, Koike, & Doi, 1990).

Two studies used bicycle ergometry (Itoh, Taniguchi, Koike, & Doi, 1990; Wilson, Fink, Ferraro, Dunkman, & Jones, 1986) and 3 used treadmill exercise testing (Dunselman et al., 1988; Lipkin, Perrins, Poole-Wilson, 1985; Weber, Kinasewitz, Janicki, & Fishman, 1982). Three studies used breath by breath respiratory gas analysis (Itoh, Taniguchi, Koike, & Doi, 1990; Lipkin, Perrins, Poole-Wilson, 1985; Wilson, Fink, Ferraro, Dunkman, & Jones, 1986). Two studies used the mixing chamber method (Dunselman et al., 1988; Weber, Kinasewitz, Janicki, & Fishman, 1982).

Five studies found that using respiratory gas analysis for determining $\dot{V}O_2$max and anaerobic threshold were useful in evaluating the severity of congestive heart failure (Itoh, Taniguchi, Koike, & Doi, 1990; Lipkin, Perrins, & Poole-Wilson, 1985 Weber, Kinasewitz, Janicki, & Fishman, 1982; Wilson, Fink, Ferraro, Dunkman, Jones, 1986). All studies compared NYHA functional classification to max$\dot{V}O_2$ determination. Those subjects who were less symptomatic had a higher max$\dot{V}O_2$ compared with those individuals who were more symptomatic and had a lower max$\dot{V}O_2$. The accepted classification system using respiratory gas analysis is that of Weber, Kinasewitz, Janicki, and Fishman (1982). This group classified subjects based upon the max$\dot{V}O_2$ determination during treadmill exercise testing. They came up with 4 categories class A to D. Subjects in functional class A had max$\dot{V}O_2$ of $<$ 20 ml/kg/min; class B had a max$\dot{V}O_2$ of 16 to 20 ml/kg/min; class C had a max$\dot{V}O_2$ of 10 to 15 ml/kg/min; and class D $<$10 ml/kg/min.

In addition to max$\dot{V}O_2$, anaerobic threshold was also found to be a reliable measure of functional capacity. The earlier anaerobic threshold appeared during exercise or the lower the $\dot{V}O_2$ at anaerobic threshold, the greater the severity of congestive heart (Itoh, Taniguchi, Koike, & Doi, 1990; Lipkin, Perrins, Poole-Wilson, 1985). Anaerobic threshold was also found to be a reliable and valid noninvasive method for determining lactate concentration in patients with congestive heart failure (Wilson, Ferraro, & Weber, 1983).

All five studies used max$\dot{V}O_2$ rather than a true $\dot{V}O_2$max determination. A true $\dot{V}O_2$max was not attained as demonstrated by plateauing of $\dot{V}O_2$ as workrate continued to increase. Instead the highest $\dot{V}O_2$ during a symptom limited exercise test was used. Weber, Kinasewitz, Janicki, and Fishman (1982) defined max$\dot{V}O_2$ as the point at which $\dot{V}O_2$ increased less than 1 ml/kg/min over that produced by the last workload.

Wilson, Fink, Ferraro, Dunkman, and Jones (1986) examined the use of maximal bicycle ergometry with respiratory gas analysis to assess functional capacity in patients with congestive heart failure. Contrary to the previous groups, these researchers found that $\dot{V}O_2$max was not detectable. When evaluating this study it is important to point out that this study is the only one which used true $\dot{V}O_2$max determination. This study demonstrates that true $\dot{V}O_2$max is difficult to obtain in patients with CHF and is probably not the appropriate definition for maximal oxygen uptake in this population.

The last study by Lipkin, Scriven, Crake, and Poole-Wilson (1986) examined the use of the six minute walking test for assessing exercise capacity in patients with chronic congestive heart failure. This group studied 26 subjects ages 36 to 68 with stable NYHA class II to III congestive heart failure. The six minute walking test consisted of subjects walking on a level corridor approximately 20 meters long. Subjects were asked to walk as much as they could in 6 minutes and were later asked to perform an exercise treadmill test with respiratory gas analysis. This group found a large variability in the 6 minute walking distance of those individuals with max$\dot{V}O_2$ <12 ml/kg/min. Variability was less in those individuals with max$\dot{V}O_2$ > 20 ml/kg/min. This group concluded that the 6 minute walking test could be useful in assessing patients who have more severe forms of CHF, but is not helpful in assessment of mild forms of congestive heart failure.

## Conclusion

The assessment of functional capacity of patients with congestive heart failure is difficult. Currently the NYHA functional classification criteria and exercise testing with or without respiratory gas analysis are used to determine functional capacity.

There are few studies which address the functional capacity of patients with congestive heart failure. Some investigators have examined physiologic predictors which may be helpful in determining functional capacity such as anaerobic threshold and resting plasma norepinephrine levels.

One difficulty in evaluating the studies reviewed is the variety of instrumentation; the exercise protocols used, the method of respiratory gas analysis, as well as the method of exercise testing (bicycle ergometry or treadmill exercise testing). The method of exercise testing has an impact on the max$\dot{V}O_2$ achieved by the individual. Maximal oxygen uptake when determined by treadmill exercise testing is noted to be approximately 10% higher than that found by bicycle ergometry (Wasserman, Hansen, Sue, & Whipp, 1987).

In addition to the variability of instrumentation, sample selection was problematic. Samples consisted of individuals with various etiologies of congestive heart failure as well as varying severity of illness. Although this broad range of patients makes the results more generalizable, it would have been helpful to examine subcategories of subjects. However, in order for this to have been performed, larger sample sizes would have been necessary.

Studies which examined functional capacity all used the NYHA functional classification criteria as the basis for comparison of the symptomatic ability of the subject to perform physical activities. No study actually attempted to assess the actual level of physical activity either by observation, monitoring or questionnaires. Therefore studies which examine the actual levels of physical activity of individuals with CHF are needed. However, studies of this nature have not been undertaken because quantification of activity levels is difficult.

## Conceptual Framework

This chapter has presented the pathophysiological mechanisms of congestive heart failure and the cardiovascular response during exercise of those individuals with congestive heart failure. In addition, self-efficacy was discussed and a review of literature concerning functional capacity assessment in individuals with CHF was also presented. The purpose of this section is to present and discuss a model which illustrates the theoretical links which form the basis for this study.

Congestive heart failure is a clinical syndrome which is caused by a variety of etiologies. The clinical signs of CHF include pulmonary edema, peripheral edema, jugular vein distention, abnormal heart sounds, and increased cardiothoracic ratio (Wenger, 1988). The symptoms of CHF are dyspnea especially with exertion, and fatigue. One of the earliest symptoms of CHF is exercise intolerance (Parmley, 1989).

The syndrome of congestive heart failure can be seen as a continuum along which any given patient will move depending upon the effectiveness of the physiologic compensatory mechanisms. For example, individuals with CHF will experience periods of acute exacerbation of symptoms which could be due to a number of insults, for example, electrolyte imbalance or arrhythmias. When exacerbation of symptoms occur medications are adjusted until the patient is again well compensated and stabilized.

As stated earlier, one of the first symptoms of CHF is exercise intolerance. The patient becomes unable to perform activities that most healthy individuals are capable of. For example walking on a flat surface becomes difficult and precipitates symptoms such as fatigue and dyspnea. These symptoms interrupt the performance of physical activity, alter the individual's perceptions of self-efficacy lowering the level of physical activity and functional capacity (see Figure 4).

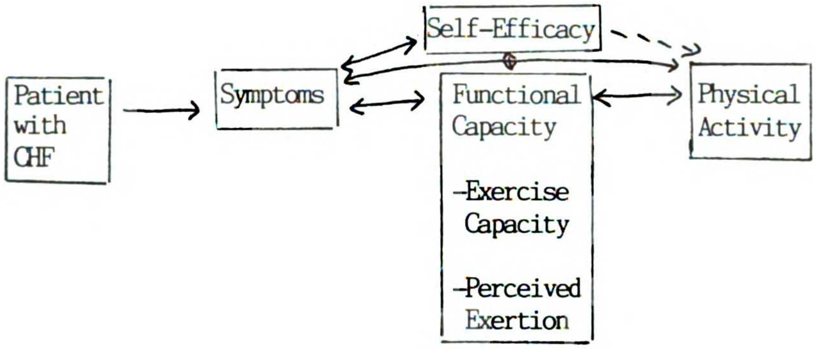

Figure 4. Conceptual Framework

Functional capacity reflects the degree to which the body is capable of coping with impaired cardiac function. Because the individuals' performance of physical activity is dependent upon the adequacy of the cardiovascular system to deliver oxygen and substrates and to remove waste products in response to exercise, these measurements are important in evaluating the functional capacity of individuals with congestive heart failure (Wasserman, 1990). Therefore, the measurement of exercise capacity by exercise testing with or without the use of respiratory gas analysis is commonly used to determine functional capacity. As functional capacity is reduced, the individuals' ability to perform physical activity is also diminished and the individual's self-efficacy beliefs are also affected. Therefore, functional capacity reflects the level of physical activity the individual is able to perform and reflects the severity of congestive heart failure.

The purpose of pharmacologic and complementary interventions is to improve an individuals' performance of physical activities or functional capacity. Therefore, the assessment of functional capacity is important to evaluate the effectiveness of various interventions.

There is much debate regarding the appropriate method to assess functional capacity. Methods currently used are the NYHA functional classification criteria, and exercise testing with or without respiratory gas analysis. None of these methods is optimal and each has inherent difficulties, yet research in this area is somewhat sparse. In addition, although the level of physical activity the individual is able to perform is the primary target of interventions, no study has examined the accuracy of these measures of functional capacity to reflect the actual level of physical activity of patients with congestive heart failure, nor has any study attempted to define the level of physical activity individuals with CHF actually perform. This study will attempt to gain access to that information by use of the Vitalog monitor, activity log, and self-efficacy activity checklists.

One can see that the severity of CHF influences the level of physical activity an individual performs. However, there are also other variables which may have a profound effect on the activity level of these individuals. These variables include self-efficacy and perceived exertion of a task.

The type of physical activity undertaken by the individual with CHF can be influenced by self-efficacy for that particular activity. If an individual has confidence in his/her ability to perform certain physical activities, it is likely that these physical activities will be attempted. The outcome of the attempt will also have an impact on future performance of this physical activity given physiologic cues. It is possible that self-efficacy may be a good indicator of functional capacity and will be examined in this study.

Perceived exertion of a particular task gives subjective information of how difficult the subject perceives the performance of a task. The ratings of perceived exertion scale can be used during exercise testing and also during activities of daily living. Perceived exertion of a task may also be an indicator of the physical activity individuals with CHF actually perform.

In conclusion, individuals with CHF experience symptoms the earliest of which is exercise intolerance as well as the symptoms of dyspnea and fatigue. Because of the inherent difficulties in assessing activity levels, assessment of functional capacity is commonly performed by the NYHA functional classification and exercise testing with or without respiratory gas analysis. This study will examine those measures of functional capacity as well as others which have not been used previously such as self-efficacy and perceived exertion and compare them with levels of physical activity as recorded by the Vitalog monitor.

## Assumptions

The assumptions upon which this study will be based include:

1. Subjects will respond to questionnaires honestly.
2. Subjects normal level of activity will not be influenced by wearing the Vitalog monitor.
3. Subjects will perform maximum effort during the exercise treadmill test.
4. The presence of the investigator, technician or cardiologist during the exercise treadmill test will not influence the performance of the subject.
5. The ambient environment of the exercise laboratory will remain constant.

## Definition of Terms

### <u>Independent Variables</u>

1. $\dot{V}O_2$max is the greatest amount of oxygen that a person can extract while performing maximal, dynamic exercise which requires a large part of the total muscle mass. It is the point at which oxygen uptake plateaus while workrate continues to rise (Wasserman, Hansen, Sue, & Whipp, 1987).

2. Maximum $\dot{V}O_2$ is the greatest amount of oxygen uptake during a symptom limited exercise test. Because the exercise test is symptom limited the plateau of oxygen consumption as in a true $\dot{V}O_2$max test may not necessarily be observed (Wasserman, Hansen, Sue, & Whipp, 1987). In this study, symptom limited treadmill exercise testing will be performed and therefore max$\dot{V}O_2$ will be measured. Workload will be determined by the modified Naughton protocol which will be discussed in greater detail in chapter three.

3. Anaerobic threshold is the point during exercise where energy production is no longer solely provided by aerobic metabolism but instead is supplemented by anaerobic metabolism in oxygen deprived tissues. This is reflected by a rise in the lactate and lactate/pyruvate ratio (Wasserman, Hansen, Sue, & Whipp, 1987). This will be measured by the change in slope of $\dot{V}E/\dot{V}O_2$ versus $\dot{V}E/\dot{V}CO_2$ during symptom-limited exercise testing.

4. Perceived exertion is an individual's perception of the amount of effort a given task requires (Borg, 1970; 1982). This will be measured by the Borg's ratings of perceived exertion scale.

5. Perceived Self-Efficacy is defined as a persons' judgment regarding their ability to organize and carry out the necessary action required of a given task (Bandura, 1986). Self-efficacy will be measured by the Jenkin's self-efficacy scales and activity checklists for walking, general activities, and health maintenance.

6. Symptoms are subjective sensations (such as dyspnea and fatigue)

which represent a complex interaction between physiologic and psychologic responses to an illness (Carrieri, Lindsey, & West, 1986).

## Dependent Variables

1. Activity involves those things an individual would normally perform on any given day. These include exercise, work, leisure activities and sexual activities (National Heart, Lung and Blood Institute, 1981).

## Other Definitions

1. Functional capacity reflects the degree of effectiveness of the compensatory mechanisms which counterbalance the effects of cardiac impairment. Functional capacity is an indirect measure of physical activity level. Functional capacity is measured by the NYHA functional classification criteria or exercise capacity via exercise testing.
2. Exercise capacity is defined as the ability of an individual to perform maximal exercise as determined by an exercise test such as a treadmill, bicycle ergometry or 6 minute walking test.

## Chapter Three

## METHODOLOGY

A prospective cohort study design was used to examine the relationship between submaximal exercise (anaerobic threshold, AT), maximal exercise (maximum oxygen uptake, max$\dot{V}O_2$), ratings of perceived exertion (RPE) during submaximal and maximal exercise and during daily activities, and self-efficacy. Subjects were followed by the investigator during the time they participated in the study, which began at the time of recruitment into the study to completion of the study. This time ranged from one week up to 3 months.

### Research Setting

The site utilized for subject recruitment and data collection was the University of California, San Francisco (UCSF) Medical Center outpatient cardiology faculty practice clinic. The UCSF Medical Center is a large teaching institution with 560 beds. It is situated in San Francisco, with patients throughout the northern California area referred for cardiac evaluation.

The cardiology clinic is located in the ambulatory care center, across from the main hospital complex. Cardiology clinic is held 4 days per week with rotating cardiology attending physicians and fellows, who were the source for subject referral. An initial computer review of current adult cardiology clinic patients with the diagnosis of congestive heart failure (CHF) and/or various types of cardiomyopathy revealed approximately 162 potential subjects for this study in the caseload.

The noninvasive cardiology department at UCSF houses the exercise treadmill laboratory. Subjects were met and assessed prior to the treadmill exercise test by the investigator at this laboratory. Clinical exercise treadmill testing was performed 2 afternoons per week between 1:00 to 2:30 p.m. Exercise treadmill testing was conducted by a technician who operated the treadmill and electrocardiographic (EKG) monitoring and a cardiologist who monitored the blood pressure (BP) and exercise response, and the investigator.

## Human Subjects Assurance

An application to the University of California, San Francisco Committee on Human Research was submitted on October 3, 1989 and approval was obtained on October 18, 1989 through October 15, 1990. Informed consent was obtained for each subject in accordance with the guidelines for the Committee of Human Research at the University of California, San Francisco (see Appendix 1). Once eligibility was determined and physician approval was received, patients were approached by the investigator and the study was described to determine subject interest. If subjects were interested, the procedures, and risks and benefits were explained and any questions were addressed at this time. Ninety three subjects were approached, of these 40 refused, 53 consented and 6 were dropped due to incomplete data.

## Sample

### Nature and Size of Sample

### Criteria for Sample Selection

The target population consisted of individuals age 30 and above with well-compensated congestive heart failure who were seen in cardiology clinic and referred by their physician. The duration of CHF in these individuals was greater than 3 months. At the time of entry into this study, subjects did not exhibit any overt signs or symptoms of CHF and were on a stable medication regimen.

Potential subjects were excluded from the study if they had any of the following: unstable angina pectoris as documented by anginal pain uncontrollable with medications and ST segment - T wave elevation or depression, dementia or confusion, obstructive valvular disease, congenital heart disease, antitachycardia pacemakers, and severe pulmonary hypertension or other severe pulmonary disease. Non-english language speaking individuals also were excluded from the study.

Forty five subjects were needed for the study, 47 participated in the study. The power analysis was performed based upon an alpha=.05, using 6 variables, and a moderate-large effect size and indicated a derived sample size of forty five, for a power of .80 (Cohen, 1988). Effect size was based upon a previous study which demonstrated a correlation between changes in self-efficacy scores for leg work and duration of self-reported leg exercise during at home activity $\underline{r}$=.34 (Ewart, Taylor, Reese, & DeBusk, 1983).

## Procedures

Potential subjects were identified by the investigator by reviewing the cardiology clinic schedule. Subject eligibility was determined and physician consent was obtained to ensure the safety of the performance of an exercise test by the subject. Once consent had been received, subject consent was obtained by the investigator. An initial interview was performed by the investigator to gather demographic data and to determine New York Heart Association (NYHA) classification. The NYHA functional classification was compared to that of the cardiologist, which was typically performed at each visit as part of the routine physical examination. There was a 95 percent agreement between the investigator and the cardiologists' NYHA classification. However, the high agreement between investigator and the cardiologist with respect to the NYHA functional classification was largely due to the range of classification used by the cardiologist. For example, patients were classified as class I to

II. On this same day an appointment was made for exercise treadmill test and placement of the Vitalog monitor. When the subject returned the Vitalog monitor was attached for 48 hours. Subjects were taught how to reconnect the leads and given a diagram that illustrated electrocardiographic lead and motion sensor placement, as they were allowed to remove the monitor while sleeping and showering. Subjects were also given instructions on the use of the activity log (see Appendix 2). An appointment for return of the Vitalog and activity log, were made. The exercise treadmill test was scheduled after the Vitalog data collection period was complete or no sooner than 24 hours after the exercise treadmill test was completed by the subject. Vitalog data were obtained only on weekdays for those individuals who worked fulltime, minimizing weekend activity variability. Because many subjects were retired and were noted to have no variation in activity level between weekdays and weekends on close questioning, those individuals were allowed to wear the Vitalog during the weekend if wearing the Vitalog during the week was not possible to schedule. A chart review was performed by the investigator to obtain other pertinent medical information such as medications and left ventricular ejection fraction (see Appendix 3).

Subjects returned for an exercise treadmill test with respiratory gas analysis. The self-efficacy expectation scale (SEES) and activity checklists (ACL) were completed by the subject within 24 hours prior to the scheduled exercise treadmill test. The investigator reviewed the SEES and ACL prior to the exercise treadmill test to ensure proper completion. After this, the subject was taken to the testing area and the treadmill EKG was attached and a resting supine, standing and hyperventilation 12 lead EKG was performed and checked for signal and abnormalities. Supine and standing blood pressures (BP) also were taken. Subjects were instructed on how to step onto the treadmill, appropriate posture for the test, and use of the face mask. The front railing was only used for balance, and not for body weight support, which was monitored by the investigator throughout the exercise treadmill test. Prior to beginning the exercise test, the use of the RPE scale was reinforced by the investigator. In addition, subjects were asked to sit in a chair so that respiratory data could be collected for one minute, allowing for detection of air leakage around the face mask before starting the exercise test. The resting period also allowed the subject to become accustomed to the face mask and reduced hyperventilation due to anxiety.

During the exercise treadmill test, HR and EKG were continuously monitored and recorded every minute with BP and RPE taken every 3 minutes. Breath by breath respiratory gas measurements were determined and stored by the computer until the end of the test when a final summary and digital and graphic output was produced. At $\text{maxVO}_2$, RPE, HR, EKG, BP and primary limiting symptom was recorded, the treadmill was stopped and subjects allowed to sit in a chair. At this time HR and EKG were continuously monitored with BP taken every 3 minutes until HR and BP had returned to preexercise levels and no

EKG abnormalities were present. Respiratory gas analysis was continued for one minute at rest. Subjects were then disconnected from the treadmill EKG and face mask and allowed to dress and leave the exercise area. After the exercise test, any questions the subject had regarding the research or the treadmill exercise test were answered.

A pilot study was conducted to establish reliability of anaerobic threshold and ratings of perceived exertion scale. Nine subjects were asked to return for a second exercise treadmill test. Interrater reliability for anaerobic threshold and NYHA classification were also determined between the investigator and a board certified cardiologist. Interrater reliability was ninety five percent for NYHA classification and 94% for anaerobic threshold.

## Data Collection Methods

### New York Heart Association (NYHA) Functional Classification

Severity of cardiac disease was determined by the NYHA functional classification criteria. The NYHA functional classification is based upon an unstructured interview performed by the clinician in which the patient's ability to perform "ordinary" activities with or without interference from symptoms is assessed. Standard questions involve distance the individual is capable of walking and the time it takes to cover that distance (an indication of speed). Because grade such as hills and stairs are considered more difficult to perform, individuals are asked the number of flights of stairs they are capable of climbing. Individuals also are asked to describe the primary limiting factor of activity, whether it is fatigue, dyspnea, angina pectoris, etc.

The individual's response is then classified from I through IV. Those individuals who are considered Class I have evidence of heart disease without any limitation of physical activity. Ordinary activity does not cause symptoms. Class II includes those individuals with heart disease in which there is a slight limitation in physical activity. Ordinary physical activity causes fatigue, dyspnea, palpitations or angina pectoris. Those individuals in Class III experience marked limitations in their ability to perform physical activity. These individuals experience symptoms with less than ordinary physical activity, although they do not experience symptoms at rest. Class IV describes those individuals with the most severe limitation of physical activity. These individuals cannot engage in any physical activity, and they experience symptoms at rest (Hurst, King, Freisinger, Walter, & Morris, 1986).

In order to determine the NYHA functional classification of subjects in this study, subjects were asked questions by the investigator about their physical activity. These included: 1) how far could they walk on level ground, 2) how long it took for them to walk that distance, 3) how many flights of stairs they could climb,

4) what was their primary limiting factor, and 5) how far could they walk uphill. Although class I patients are easily identified, the distinction between Class II-IV is more difficult (Goldman, Hashimoto, Cook, & Loscalzo, 1981). Accurate assessment of a patient is dependent upon the level of experience of the clinician, the rapport between the patient and clinician, and the ability of the patient to describe the level of physical activity they are capable of performing.

## Exercise Testing

A physician supervised treadmill exercise test in the noninvasive laboratory at the University of California, San Francisco was performed using a Marquette treadmill with continuous 12 lead EKG monitoring. Maximum oxygen uptake was determined for this study by the highest $\dot{V}O_2$ achieved during a symptom-limited exercise test (Wasserman, Hansen, Sue, & Whipp, 1987). The modified Naughton treadmill protocol was used in which the workload is divided into 3 minute stages beginning at 0% grade at 1 mph (stage 0). At stage I, the speed increases to 1.5 mph at 0% grade. At stage III, the speed increases to 2 mph and the grade increases to 3.5% (see Appendix 4). The treadmill exercise test was discontinued upon: 1) subject request, 2) EKG changes associated with myocardial ischemia (ST depression >.2mV), 3) angina grade 2+ on a scale 0 to 3+, 4) significant cardiac arrhythmias, 5) hypotension, 6) hypertension (systolic >200mmHg, or diastolic >100), or 7) dyspnea or fatigue which prohibited the patient from going any further. In 4 cases the exercise test was stopped by the investigator or the cardiologist because of objective signs of ischemia or abnormal exercise response.

Maximal Oxygen Consumption ($\dot{V}O_2max$). In this study, maximum $\dot{V}O_2$ was determined by breath by breath analysis, using a Sensormedics MMC Horizon System 4400, metabolic cart. A face mask was connected to a digital volume transducer, which allowed bidirectional flow of both inhaled and exhaled gas. Air flowing through the cartridge bore spins a lightweight helical impeller which is supported on cushion mounted sapphire jewel bearings. Four infrared light beams cross the flowmeter core in the impeller path. As the impeller rotates, it sequentially interrupts the light beams producing four trains of digital pulses. These signals are processed and the flow direction, flow rate, and total volume are determined. The standard digital volume transducer produces 500 electrical impulses per liter of volume with an accuracy of 1.5% in the range of 0.05 liters/second to 15 liters/second. The turbine produces a minimal amount of resistance to breathing even at high flow rates. A sampling line composed of 1.00 millimeter teflon tubing was connected to the turbine flow valve piece and a sample of gas was taken at every breath and was directed from the subject to oxygen ($O_2$) and carbon dioxide ($CO_2$) analyzers.

The metabolic analysis system used was the MMC Horizon 4400 which incorporates two microprocessor systems. The Hewlett-Packard (HP) 9816 system model online computer was used to operate and perform the necessary calibrations, calculations and to communicate with the data acquisition computer. The data acquisition computer reads the data from the volume sensor and gas analyzers 100 times per second. The computer then generates $\dot{V}O_2$, minute ventilation ($\dot{V}E$), $CO_2$ production ($\dot{V}CO_2$), end-tidal $O_2$ ($PetO_2$), end-tidal $CO_2$ ($PetCO_2$), heart rate (HR), respiratory quotient (RQ) and metabolic cost in metabolic equivalents (METS) which is printed out on the HP jet printer. Calibration of the metabolic cart was performed prior to each exercise test, using preanalyzed balanced calibration 24% $O_2$ and 8% $CO_2$ gas.

In this study max$\dot{V}O_2$ was determined as the highest $\dot{V}O_2$ achieved during a symptom limited exercise treadmill test. All subjects were encouraged to exercise until they felt they were unable to continue. Accuracy was enhanced by directing subjects not to grip handrails and by the investigator monitoring this throughout the exercise test. In addition, subjects were given several minutes to become accustomed to the face mask so that hyperventilation due to anxiety was not a factor.

The reliability of max$\dot{V}O_2$ may be affected by the treadmill apparatus, primarily the calibration of height and speed of the belt (Holly, 1988). One treadmill was consistently used for this study to ensure reliability of treadmill belt speed and height. In addition, reliability of max$\dot{V}O_2$ measurements for subjects was determined by test-retest of 9 subjects.

Anaerobic Threshold. In this study, anaerobic threshold was determined by the respiratory gas exchange method as the point at which the ratio of increases $\dot{V}E/\dot{V}O_2$ disproportionately to the ratio of $\dot{V}E/\dot{V}CO_2$. Anaerobic threshold was expected at approximately 60%-70% $\dot{V}O_2$max and near a respiratory quotient (RQ) of one (Lipkin, Bayliss, & Poole-Wilson, 1985). The correlation between anaerobic threshold and lactate concentration in patients with CHF has been demonstrated to be .96 (Matsumura et al., 1983).

Stability of anaerobic threshold was assessed in this study by retesting 9 subjects who consented to perform a second exercise test with respiratory gas analysis. These subjects were retested at their convenience, provided there were no changes in their clinical status between the first and second exercise test.

Ratings of Perceived Exertion (RPE) In this study, the 0-10 category RPE scale with simple verbal anchors was used to evaluate perceived exertion (Borg, 1982) (see Appendix 5). Subjects were asked to rate their level of "general" exertion, or how hard they felt they were working at that particular moment, on a scale of 0 = nothing at all, to 10 = very, very strong, maximal. The RPE was administered by the investigator at the end of each stage of the exercise test after a blood pressure had been taken, and at anaerobic threshold and $\max\dot{V}O_2$, and was also self-administered during performance of daily activities which was done during the activity monitoring period. Reliability of the RPE scale was assessed in this study by comparing the RPE scale at submaximal (AT) and maximal exercise levels in 9 subjects who were retested.

Symptoms Symptoms which limit exercise were determined by asking subjects at $\max\dot{V}O_2$ why they stopped exercising. Subjects chose one primary symptom: dyspnea, general or leg fatigue, angina or other and these were recorded onto an exercise record that was kept during the treadmill exercise test.

Activity Level The level of daily activity the individual was able to perform was determined by 2 methods, the Vitalog ambulatory monitor that records arm and leg motion and HR, and the activity checklists for general activities, walking, and health maintenance (developed by L. Jenkins, 1989).

Vitalog. The Vitalog provided data for the most strenuous activity performed by subjects either prior to the treadmill exercise test or no sooner than 24 hours after the treadmill exercise test was completed. An activity log was used in conjunction with the Vitalog to record events which helped explain recorded HR and arm and leg motion (see Appendix 6).

The MC2 Vitalog monitor is a solid-state microprocessor, approximately 4x8x12 cms, which weighs 0.5kg and is worn on a belt. Rechargeable batteries provide power for at least 100 hours. The Vitalog uses 3 chest EKG electrodes and determines HR by detecting R-R intervals. Body movements are detected by one motion sensor placed on the anterior upper thigh and a second on the forearm of the nondominant arm. Movement is analyzed per minute by the opening and closing of the mercury switch in the motion sensor. These numbers are then sorted in 1 of 64 logarithmically increasing levels which make up the bin structure for data storage. This information is stored in conjunction with the HR per minute (Taylor et al., 1984). Reproducibility utilizing the Vitalog for with-in week average HR yields $\underline{r}$=.77, and the value for between-week average HR is $\underline{r}$=.86 (Mueller et al., 1986).

Both HR and arm and leg motion were used to determine a HR-motion relationship during what the subject considered the most strenuous activity performed on the day that the Vitalog was worn. The combination of HR and motion determines whether an elevation in either measure is because of physical activity or small muscular movements such as shaking an arm or leg, or other causes such as emotions.

The Activity Check Lists (ACL) in which the subject recalls whether the identical activities ranked in the self efficacy expectation scales were performed by the individual within the past

24 hours was completed 24 hours prior to the exercise treadmill test. These activities were rated as "yes", "no" or "not applicable". The score for the ACL was the sum of the yes responses for scale. Measures of internal consistency for the general activity scale range from .76 to .86, for the walking scale from .93 to .96 and for the health maintenance scale .43 (Jenkins, 1989).

Self-Efficacy Expectation Scales. Self-efficacy expectation scales (SEES) with their corresponding activity checklists (ACL) were used to assess self-efficacy perceptions for physical activity (Jenkins, 1989) (see Appendix 7). Because perceptions are specific to a particular activity, the relevant behavioral domains of walking, general activity and health maintenance were used in this study (Gortner, Houston-Miller, & Jenkins, 1988). Both the SEES and ACL were self-administered 24 hours prior to the exercise test and took the subject approximately 15 minutes to complete. The subject was asked to rank a specified activity on a scale from 0 = definitely cannot do to 10 = definitely can do. The SEES score was derived by summing the numerical responses and dividing by the number of items on the scale. This score reflects the level of perceived self-confidence for that particular activity (Gortner, Houston-Miller, & Jenkins, 1988). Measures of internal consistency for the general activity SEES range from .82 to .99, for walking from .94 to .95, and for the health maintenance .85 (Jenkins, 1989).

## Data Analysis

Characteristics of the sample were analyzed using descriptive statistics. The Pearson product moment correlation coefficient was used to examine the relationship between the variables: anaerobic threshold, maximum oxygen uptake, ratings of perceived exertion at anaerobic threshold and at maximum oxygen uptake, self-efficacy and activity level. To determine the predictors of activity levels, a multivariate regression analysis was performed between the independent variables: anaerobic threshold, maximum oxygen uptake, ratings of perceived exertion at anaerobic threshold and at maximum oxygen uptake, self-efficacy expectation and self-reported activity and the dependent variable activity levels (heart rate and arm and leg motion).

## Chapter 4

## RESULTS

This chapter will describe study results beginning with demographic characteristics of the sample. A description of functional capacity follows which includes exercise capacity and functional assessment by the NYHA functional criteria and the Weber classification as well as activity recorded by the Vitalog monitor and perceived self-efficacy expectation. Analysis of variance was used to examine the difference between groups, the NYHA functional and Weber classes with respect to demographic characteristics, exercise capacity, Vitalog data and perceived self-efficacy expectation. Multivariate analysis was also used to determine predictors of activity levels in patients with congestive heart failure.

### Characteristics of the Sample

The demographic characteristics of this sample are included in Table 1. The sample consisted of 47 subjects of which a majority were males (39, 83%), 8 (17%) were females. The mean age of the sample was 60 years (33-91) which was lower than that described in the epidemiologic data (Kannel, 1989). According to Kannel (1989) the highest annual incidence of congestive heart failure occurred between the ages of 69 to 94 (Kannel, 1989). This difference between the epidemiologic findings and the sample of this study are most likely due to the number of younger subjects who were diagnosed with idiopathic cardiomyopathy being considered for heart transplantation who were included in this study. There were 4 subjects between the ages of 33 to 38, 7 between the ages of 40 to 49, 11 from 52 to 59, 12 from 60 to 68, 11 ages 70 to 78 and 1 80 and 1 90 year old. Although the majority of the sample were over 60 (25), 22 were below the age of 60 reflecting a younger age distribution than that found in the literature.

There was ethnic diversity of the sample probably due to the location of the medical center in the city of San Francisco which has a unique blend of a variety of ethnicities which may not be representative of most other cities throughout the United States. The majority of the sample were white (27, 57%), followed by African-Americans (9, 19%), Asian-Americans (6, 13%), Latino (3, 6%), and Middle-Easterners (2, 2%).

Most individuals were married (28, 60%). Eight (17%) were single, 6 (13%) were divorced, 4 (9%) were widowed and 3 (4%) lived with a significant other. The average length for their relationship was 21 years. Most subjects lived in a house with their immediate family consisting of an average of 2 children. To determine whether stair climbing was a part of their normal routine, the number of steps at the place of residence was determined by interview. The average number of steps at the place of residence was 8 (0 to 16 steps), and all subjects stated that they had no problems climbing the steps in their home.

The occupational composition of the sample was not surprising given the age of the sample. The majority of individuals were retired (32, 68%) for an average of 6 years (range 0 to 30 years). The professions of those who continued to work at the time the study was conducted were 2 (4%) professional, 5 (11%) white collar, 7 (15%) blue collar and 1 (2%) who did not fit any of the above categories. The average length of education was 14 years (range 5 to 23 years).

Table 1. Characteristics of the Sample

| Variable | Frequency | Percent |
|---|---|---|
| Gender | | |
| males | 39 | 83% |
| females | 8 | 17% |
| Ethnicity | | |
| Af. American | 9 | 19% |
| Asian | 6 | 13% |
| Latino | 3 | 6% |
| White | 27 | 57% |
| Other | 2 | 4% |
| Marital Status | | |
| Single | 8 | 17% |
| Married | 28 | 60% |
| Divorced | 6 | 13% |
| Widowed | 4 | 9% |
| Cohabit | 1 | 2% |
| Occupation | | |
| Retired | 32 | 68% |
| Professional | 2 | 4% |
| White Collar | 5 | 11% |
| Blue Collar | 7 | 15% |
| Other | 1 | 2% |
| Type of residence | | |
| House | 38 | 81% |
| Apartment | 9 | 19% |

| Variable | Frequency | Percent |
|---|---|---|
| **Live with** | | |
| alone | 11 | 23% |
| family | 34 | 72% |
| roommate | 3 | 4%. |
| **Problems with steps** | | |
| no | 47 | 100% |

| Variable | Mean | SD | range | N |
|---|---|---|---|---|
| Age | 60 | 13 | 33-91 | 47 |
| Length of marriage (yrs) | 21 | 17 | 0-54 | 37 |
| No. of Children | 2 | 2 | 0-9 | 45 |
| No. of years retired | 6 | 8 | 0-30 | 42 |
| No of years of education | 14 | 4 | 5-23 | 47 |
| No. of steps at residence | 8 | 8 | 0-24 | 47 |

## Characteristics of Congestive Heart Failure

Characteristics of CHF for this sample are included in Table 2. Subjects were included in this study if they had experienced an episode of CHF in the past with a duration of greater than 3 months and were well compensated at the time of participation in the study. The most common primary diagnosis for CHF was coronary artery disease or myocardial infarction (26, 55%), of these, 3 or 6% underwent coronary artery bypass surgery. The next most common cause for CHF was idiopathic cardiomyopathy (17, 36%). Two (4%) subjects had hypertension, 1 (2%) alcoholic cardiomyopathy, and 1 (2%) each had surgery for valvular disease, aortic valve replacement and mitral valve replacement. Individuals with valve replacement experienced at least one episode of CHF after surgical replacement of the faulty valve, but were considered stable at the time of entry into this study. These data reflect the epidemiologic pattern of congestive heart failure described by Parmley (1989).

A chart review was used to determine ejection fraction of each subject. The mean ejection fraction at rest of 46 individuals was 32 (range 14 to 57). The method used to determine ejection fraction in these 46 individuals were nuclear wall motion (17, 39%), echocardiography (21, 48%), and angiography (6, 14%). The ejection fraction for one subject was not available.

At the time of enrollment into this study, subjects were considered to be in well-compensated congestive heart failure, which meant that subjects were on stable doses of medications which adequately controlled symptoms of congestive heart failure. The most common medication regimen for patients with CHF due to left ventricular dysfunction is digoxin, diuretics and ace inhibitors (Parmley, 1989) which are reflected in this sample. Thirty one (67%) subjects were prescribed digoxin, 34 (72%) diuretics, and 27 (57%) ace inhibitors. However, because of the variety of etiologies of CHF included in this sample, other medications also were prescribed for this group, these include nitrates (14, 30%), calcium channel blockers (11, 32%), beta blockers (7, 15%), antiarrhythmics (6, 13%), vasodilators (2,4%) or other cardiovascular medication not included in this list.

Table 2. Characteristics of CHF in the study sample

| Characteristics | Frequency | Percent |
|---|---|---|
| Primary Etiology for CHF | | |
| CAD/MI | 26 | 55% |
| Idiopathic CM | 17 | 36% |
| Hypertension | 2 | 4% |
| Alcoholic CM | 1 | 2% |
| AVR/MVR | 2 | 4% |
| Method Used for Determination of Ejection Fraction | | |
| Echocardiography | 21 | 48% |
| Nuclear Wall Motion | 17 | 39% |
| Angiography | 6 | 14% |
| Medications | | |
| Diuretic | 34 | 72% |
| Digoxin | 31 | 67% |
| Ace Inhibitor | 27 | 57% |
| Nitrates | 14 | 30% |
| Calcium channel Blocker | 11 | 23% |
| Beta Blocker | 7 | 15% |
| Antiarrhythmic | 6 | 13% |
| Vasodilator | 2 | 4% |
| Other | 2 | 4% |

| Variable | Mean | SD | Range | N |
|---|---|---|---|---|
| Ejection Fraction | 32 | 12 | 14-57 | 46 |

## Characteristics of Functional Capacity

Functional capacity was assessed using the New York Heart Association (NYHA) functional classification and Weber classification criteria and the results are shown in Table 3. According to the NYHA functional class, a majority of the subjects experienced some symptoms which limited ordinary physical activity and were considered class II (21, 45%). Eleven (23%) subjects were considered class I and experienced no symptoms during ordinary physical activity and were not limited in their physical activities. Fifteen or 32% of subjects had marked limitations in physical activity and less than ordinary physical activity caused symptoms, although they were symptom-free at rest (class III). There were no individuals who could be described as class IV; could not engage in any kind of physical activity because of symptoms and were symptomatic at rest.

The Weber classification is based upon the maximal oxygen uptake individuals achieved during the exercise test. This sample had a lower maximal oxygen uptake compared to age matched healthy individuals (Hanson, 1988). In this sample, the majority of subjects were considered class C and had a maximal oxygen uptake of 10-15 ml/kg/min (n=24, 51%), while class B (n=10, 23%) and class A were almost comparable in number (n=11, 21%) and had a maximal oxygen uptake respectively of 16-20 ml/kg/min and greater than 20 ml/kg/min. Only two (4%) individuals were classified as class D with a maximal oxygen uptake of less than 10 ml/kg/min.

Table 3. Characteristics of functional capacity

| Characteristics | Frequency | Percent |
|---|---|---|
| New York Heart Association Functional Classification | | |
| Class I | 11 | 23% |
| Class II | 21 | 45% |
| Class III | 15 | 32% |
| Weber Classification | | |
| Class A | 10 | 21% |
| Class B | 11 | 23% |
| Class C | 24 | 51% |
| Class D | 2 | 4% |
| Characteristics | Frequency | Percent |
| Most Strenuous Type of Daily Activity Performed | | |
| Walking, flat | 22 | 47% |
| Walking,hills,steps | 1 | 2% |
| lifting | 1 | 2% |
| general activity | 19 | 40% |
| recreational | 4 | 9% |
| Symptom Experienced During Daily Activity | | |
| No Symptoms | 23 | 49% |
| Dyspnea | 10 | 21% |
| Fatigue | 7 | 15% |
| Sore Muscles/Joints | 7 | 15% |

## Characteristics of Exercise Capacity

Sample characteristics of exercise capacity are included in Table 4. The average height was 70 inches (+/- 16, range 59 to 176 inches) and the average weight for this sample was 164 pounds (+/- 35 pounds, range 72 to 235 pounds). Other important variables to consider when interpreting respiratory gas analysis data are minute ventilation (VE) and maximum voluntary ventilation (MVV). These two variables help to determine whether a baseline pulmonary abnormality exists which would alter oxygen uptake. By eliminating pulmonary abnormalities one can deduce that if maximum oxygen uptake is reduced it may be a result of a cardiovascular disturbance or a cellular, metabolic abnormality. The mean minute ventilation for this sample was 45.53 (+/- 14.05, range 27 to 78). The mean maximum voluntary ventilation was 67.80 (+/- 21.50, range 27 to 116). The percent of predicted maximum voluntary ventilation for this sample was 117.52 (+/- 1.20, range 77.87 to 161.83).

The average maximal oxygen uptake (max$\dot{V}O_2$) for this sample was 1256.85 ml/min (+/- 539, range 637 to 2798 ml/min) or 16.76 ml/kg/min (+/- 6.4, range 7.4 to 40 ml/kg/min). The respiratory quotient (RQ) at submaximal exercise or at anaerobic threshold was .92 (+/- .073, range .75 to 1.03) and increased to 1.04 (+/- .12, range .79 to 1.42) at maximal exercise which suggests that subjects put forth a maximal effort during exercise testing. Only 35 of 47 (74%) subjects had a distinguishable anaerobic threshold (AT). Anaerobic threshold in these 35 subjects occurred at 9.42 minutes (+/- 4.15, range 2 to 21 minutes) at an oxygen uptake of 13.03 ml/kg/min (+/- 4.01, range 8 to 25.9 ml/kg/min), and at 75% (+/- 9.4%, range 56% to 90%) of maximal oxygen uptake.

Table 4. Characteristics of Exercise capacity

| Characteristics | Mean | SD | Range | N |
|---|---|---|---|---|
| Height | 70" | 16 | 59-176 | 47 |
| Weight | 163.8 lbs | 35 | 72-234 | 47 |
| MVVmax | 67.8 | 26 | 31-141 | 47 |
| MVVpredicted | 118 | 20 | 78-162 | 42 |
| MVVpercent | 60 | 21 | 24-116 | 42 |
| $\dot{V}E$ | 45.55 | 14 | 27-78 | 47 |
| $\dot{V}T$ | 1.53 | .48 | .80-2.68 | 47 |

| Characteristics | Mean | SD | Range | N |
|---|---|---|---|---|
| max$\dot{V}O_2$(ml/min) | 1256.85 | 539 | 637-2798 | 47 |
| max$\dot{V}O_2$(kg/ml/min) | 16.76 | 6.45 | 7.4-40 | 47 |
| RQ | 1.04 | .12 | .79-1.42 | 47 |
| ATRQ | .92 | .07 | .75-1.03 | 35 |
| AT$\dot{V}O_2$(kg/ml/min) | 13.03 | 4.01 | 8-25.9 | 35 |
| ATtime | 9.42" | 4.15" | 2-21 | 35 |
| ATpercent | .75 | .1 | .56-.9 | 35 |
| RPE at AT | 3.76 | 1.35 | 1-7 | 35 |
| RPE at $\dot{V}O_2$max | 6.45 | 2.0 | 1-10 | 47 |
| HR at rest | 77 | 13 | 54-113 | 39 |
| HR at max Ex | 129 | 22 | 86-174 | 39 |
| HR at submax EX | 108 | 18 | 86-147 | 28 |
| HR reserve EX | 52 | 18 | 21-86 | 39 |
| SBP at rest | 123 | 21 | 82-177 | 47 |
| SBP at max EX | 158 | 29 | 111-220 | 47 |
| DBP at rest | 72 | 11 | 50-99 | 47 |
| DBP at max EX | 79 | 18 | 45-130 | 47 |
| RPP | 20319.6 | 4714 | 13596-30800 | 39 |
| max METS | 4 | 2 | 1-11 | 47 |
| Ex duration | 13.56" | 6.33" | 1.5-33 | 47 |

| Characteristic | Frequency | Percent |
|---|---|---|
| Reason for termination of exercise test | | |
| Dyspnea | 13 | 28% |
| Fatigue | 24 | 51% |
| Angina | 5 | 11% |
| Hypotension | 1 | 2% |
| Hypertension | 1 | 2% |
| Arrhythmia | 1 | 2% |
| Leg Pain | 1 | 2% |
| Other | 1 | 2% |

Ratings of perceived exertion at anaerobic threshold (RPEAT) were 3.76 "moderate to somewhat strong" (+/- 1.35, range 1 to 7) compared to 6.45 "strong to very strong" (+/- 2.01, range 1 to 10) at maximal oxygen uptake (RPEmax).

In this sample, there were 8 individuals who had a baseline electrocardiographic rhythm of atrial fibrillation. Due to the irregular heart rate with this rhythm, these 8 individuals were eliminated from analyses which required heart rate, such as heart rate at rest, during submaximal and maximal exercise, reducing the sample size to 39 for these analyses. The average heart rate (HR) during Vitalog monitored physical activity, submaximal and maximal exercise were analyzed separately for these individuals and the results are included in Table 5.

Table 5. <u>HR response in individuals with atrial fibrillation</u>

| Variable | Mean | SD | Range | N |
|---|---|---|---|---|
| HR at rest | 79 | 13 | 58-100 | 8 |
| HR activity | 92 | 12 | 69-112 | 8 |
| HR at submax EX | 122 | 18 | 95-140 | 8 |
| HR max EX | 147 | 31 | 109-196 | 8 |
| HR reserve during EX | 68 | 31 | 31-124 | 8 |
| HR reserve activity | 12.25 | 11 | -3-28 | 8 |
| RPP | 22571 | 8111 | 15624-37240 | 8 |

When the heart rate response of the 8 subjects with atrial fibrillation were analyzed, it was found that heart rate at rest was 79 beats per minute (BPM) (+/- 13, range 58 to 100 BPM). Heart rate during submaximal exercise was 122 BPM (+/- 18, range 95 to 140 BPM), which increased to an average of 147 BPM (+/- 31, range 109 to 196 BPM) during maximal exercise. During Vitalog monitored physical activity heart rate averaged 92 BPM (+/- 12, range 69 to 112 BPM). In addition to measured heart rate, heart rate reserve was calculated as the difference between heart rate at rest and heart rate during maximal exercise, and the difference of heart rate at rest and during Vitalog monitored physical activity. When HR reserve was examined for the subjects with atrial fibrillation, it was found that heart rate reserve during exercise was 68 BPM (+/- 31, range 31 to 124 BPM), and during Vitalog monitored physical activity heart rate reserve was 12 (+/- 11, range -3 to 28 BPM).

In contrast to subjects with atrial fibrillation the heart rate at rest for all other subjects (n=39) was similar to those with atrial fibrillation 77 BPM (+/- 13, range 54 to 113 BPM) (see Table 4). Heart rate during submaximal exercise was lower in subjects with normal sinus rhythm than those with atrial fibrillation, 108 BPM (+/- 18, range 86 to 147 BPM), that increased to a mean of 129 BPM, also lower than those with atrial fibrillation (+/- 22, range 86 to 174 BPM). During Vitalog monitored physical activity heart rate was 89 BPM, again lower than individuals with atrial fibrillation (+/- 12, range 54 to 111 BPM). When heart rate reserve during Vitalog monitored physical activity was calculated the mean was 8.9 BPM (+/- 12, range -9 to 45), while that during maximal exercise increased to 52 BPM (+/- 18, range 21 to 86).

Systolic blood pressure at rest was 123 mmHg (+/- 21, range 82 to 177 mmHg), which increased to 158 mmHg (+/- 29, range 111 to 220 mmHg) at maximal exercise (see Table 4). The average diastolic blood pressure at rest was 72 mmHg (+/- 11, range 50 to 99 mmHg) compared to 79 mmHg (+/- 18, range 45 to 130 mmHg) at maximal exercise. The rate pressure product (RPP) an index of myocardial efficiency was derived by the product of maximal heart rate during exercise and maximal systolic blood pressure which for the sample excluding individuals with atrial fibrillation was 20319.6 (+/- 4714, range 13596 to 30800). Rate pressure product was higher for those 8 subjects with atrial fibrillation, 22571 (+/- 8111, range 15624-37240).

The exercise duration for this group was 13.56 minutes with an average of 4 metabolic equivalents at maximal exercise (maxMETS). The primary reason for termination of the treadmill exercise test was fatigue in 24 (51%) subjects, while 13 (28%) stated that dyspnea was the primary reason for stopping exercise. Five (11%) stopped because of angina pectoris, 1 (2%) due to leg pain and 1 (2%) because of other symptoms. The exercise test was discontinued by the investigator in 3 subjects because of hypotension (1, 12%), hypertension (1, 2%), and ventricular arrhythmias (1, 2%).

## Level of activity

### Vitalog

The Vitalog data were analyzed by determining the time of the most strenuous activity and determining the average heart rate, and the average number of arm and leg clicks for that period of time (see Table 6). The mean period of physical activity analyzed was one hour. The average heart rate for the most strenuous activity for 39 subjects was 86 BPM (+/- 12, range 57 to 111 BPM). Those individuals with atrial fibrillation had an average heart rate during activity of 92 BPM (+/- 12, range 69-112). The average number of arm clicks was 29 per minute (+/- 25, range 0 to 104). The average for leg clicks was 13 (+/- 24, range 0 to 148). The average rating of perceived exertion was 4 or "somewhat strong" (+/- 2, range .5 to 10).

Table 6. Characteristics of Vitalog monitored physical activity levels

| Variable | Mean | SD | Range | N |
|---|---|---|---|---|
| HR activity | 86 | 12 | 57-111 | 39 |
| HR reserve activity | 9 | 12 | -9-45 | 39 |
| Arm | 29 | 25 | 0-104 | 47 |
| Leg | 13 | 24 | 0-149 | 47 |
| RPE activity | 4 | 2 | .5-10 | 47 |

Walking on a flat surface was the most strenuous activity performed by 47% (22) of subjects while 19 (40%) noted that the activity was more general in nature and consisted of housework or household chores. Four (9%) said the activity was recreational in nature, one (2%) said the most strenuous activity consisted of lifting boxes, while another person described (2%) walking uphill as the most strenuous activity performed.

## Symptoms

Subjects were also asked to record the symptoms that they experienced during the most strenuous Vitalog monitored physical activity. It was found that 23 (49%) had no symptoms during activity, while 10 (21%) noted dyspnea, 7 (15%) fatigue, and 7 (15%) recorded sore muscles/joints to be the primary symptoms experienced with Vitalog monitored physical activity.

Thirty percent of subjects who did not experience symptoms were walking on a flat surface, 52% were performing general types of activity, 13% recreational and 4% reported lifting boxes. Of those individuals who experienced dyspnea, 70% were walking on a flat surface, 20% general activity and 10% were performing recreational activities. Fatigue was also a symptom experienced by 15% of the subjects, of which 86% were walking on a flat surface, and 14% were performing general activities. Fifteen percent of individuals experienced sore muscles/joints of which 57% performed general activities, 28% were walking on a flat surface and 14% walking up steps.

When subjects were compared according to the New York Heart Association functional class, 48% of those with no symptoms were considered class II, 39% were class III and 13% class I. Subjects who experienced dyspnea were equally distributed into class I and II (40%) and 20% were class III. Of those individuals who experienced fatigue, 43% were class III and 29% were class I and class II. Fifty seven percent of individuals with sore muscles/joints were considered class II, 29% class I and 14% class III.

When symptoms experienced during Vitalog monitored physical activity were compared with exercise capacity it was found that there were no differences among individuals with no symptoms, dyspnea, fatigue or sore muscles/joints with respect to maximal oxygen uptake, oxygen uptake at anaerobic threshold, maximal metabolic equivalents, exercise duration, or maximal heart rate. (see Table 7). There was a difference between symptoms experienced during Vitalog monitored physical activity and the percent of maximal oxygen uptake at which anaerobic threshold occurred. A post-hoc analysis revealed that individuals with no symptoms during Vitalog monitored physical activity reach anaerobic threshold at a lower percent of maximal oxygen uptake than those who experience dyspnea. Subjects with no symptoms during Vitalog monitored physical activity reach anaerobic threshold at a lower percentage of maximal oxygen uptake than those who experience fatigue, while those with dyspnea achieve a greater percent of maximal oxygen uptake at anaerobic threshold than those with fatigue, although these results did not reach statistical significance.

Table 7. Relationship between symptoms during Vitalog monitored physical activity and exercise capacity

Percent of maximal oxygen uptake at anaerobic threshold

Means and Standard Deviations

| Variable | Mean | SD |
|---|---|---|
| No symptoms | .71 | .09 |
| Dyspnea | .83 | .05 |
| Fatigue | .72 | .09 |

Fmax for testing homogeneity of between subjects variances: 2.86

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between Subjects | | | | |
| Symptoms | 2 | .0362 | 5.33 | .01 |
| Error | 27 | .0068 | | |

Post-hoc tests for factor symptoms during activity

| Level | Mean |
|---|---|
| No symptoms | .713 |
| Dyspnea | .831 |
| Fatigue | .724 |

Comparison Scheffe'

No symptoms < Dyspnea p=.01
No symptoms < Fatigue
Dyspnea > Fatigue

Maximal oxygen uptake (ml/kg/min)

**Means and Standard Deviations**

| Variable | Mean | SD |
|---|---|---|
| No symptoms | 18.92 | 7.49 |
| Dyspnea | 15.74 | 5.09 |
| Fatigue | 13.76 | 4.88 |

Fmax for testing homogeneity of between subjects variances: 2.35

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between subjects | | | | |
| Symptoms | 2 | 86.05 | 1.977 | ns |
| Error | 37 | 43.54 | | |

Maximum Metabolic Equivalents during maximal exercise test

**Means and Standard Deviations**

| Variable | Mean | SD |
|---|---|---|
| No symptoms | 5.0 | 2.39 |
| Dyspnea | 3.9 | 1.73 |
| Fatigue | 4.0 | 2.08 |

Fmax for testing homogeneity of between subjects variances: 1.92

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between Subjects | | | | |
| Symptoms | 2 | 5.5 | 1.138 | ns |
| Error | 37 | 4.8351 | | |

Exercise duration

**Means and Standard Deviations**

| Variable | Mean | SD |
|---|---|---|
| No symptoms | 15.09 | 7.06 |
| Dyspnea | 12.16 | 5.33 |
| Fatigue | 12.39 | 5.88 |

Fmax for testing homogeneity of between subjects variances: 1.75

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between subjects | | | | |
| Symptoms | 2 | 39.35 | .934 | ns |
| Error | 37 | 42.14 | | |

Maximal heart rate achieved during exercise test

**Means and Standard Deviations**

| Variable | Mean | SD |
|---|---|---|
| No symptoms | 135.89 | 21.28 |
| Dyspnea | 125.10 | 22.32 |
| Fatigue | 131.40 | 14.31 |

Fmax for testing homogeneity of between subjects variances: 1.97

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between Subjects | | | | |
| Symptoms | 2 | 627.25 | 1.561 | ns |
| Error | 31 | 433.93 | | |

The difference between the limiting symptom during Vitalog monitored physical activity and that experienced during treadmill exercise test was examined using a kappa statistical analysis. This test addresses the probability of the symptoms occurring by random chance alone and the percent of agreement among symptoms experienced during activity and during maximal exercise.

The primary limiting symptom during maximal exercise was fatigue in 51% and dyspnea in 28% of this sample. During Vitalog monitoring it was noted that 49% of the sample did not experience any symptoms, 21% complained of dyspnea, 15% of fatigue and 15% of sore muscles/joints. The percentage of agreement between the primary limiting symptom during maximal exercise and during Vitalog monitored physical activity was also examined. It was found that 42% experienced fatigue during both maximal exercise and activity while 40% experienced dyspnea.

Vitalog monitored physical activity levels and ratings of perceived exertion during physical activity were compared between individuals with varying symptoms during Vitalog monitored physical activity and the results are shown in Table 8. Table 9 includes other measures such as perceived self-efficacy expectation for walking, activity and health maintenance and the corresponding self-reported activity checklists.

Table 8. Relationship between symptoms and RPE experienced during Vitalog monitored physical activity and activity levels

Heart Rate during Vitalog monitored physical activity

**Means and Standard Deviations**

| Variable | Mean | SD |
|---|---|---|
| No symptoms | 85.42 | 10.10 |
| Dyspnea | 87.10 | 8.86 |
| Fatigue | 84.60 | 17.78 |

Fmax for testing homogeneity of between subjects variances: 4.03

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between subjects | | | | |
| Symptoms | 2 | 13.41 | .109 | ns |
| Error | 31 | 122.8623 | | |

Arm motion

**Means and Standard Deviations**

| Variable | Mean | SD |
|---|---|---|
| No symptoms | 28.87 | 27.90 |
| Dyspnea | 26.15 | 29.54 |
| Fatigue | 38.47 | 21.17 |

Fmax for testing homogeneity of between subjects variances: 1.95

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between Subjects | | | | |
| Symptoms | 2 | 339.66 | .454 | ns |
| Error | 37 | 747.90 | | |

Leg motion

**Means and Standard Deviations**

| Variable | Mean | SD |
|---|---|---|
| No symptoms | 7.62 | 6.14 |
| Dyspnea | 10.87 | 20.09 |
| Fatigue | 29.07 | 53.42 |

Fmax for testing homogeneity of between subjects variances: 75.63

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between Subjects | | | | |
| Symptoms | 2 | 1246.62 | 2.137 | ns |
| Error | 37 | 583.46 | | |

## Ratings of perceived exertion during Vitalog monitored physical activity

### Means and Standard Deviations

| Variable | Mean | SD |
|---|---|---|
| No symptoms | 3.30 | 1.97 |
| Dyspnea | 5.30 | 2.58 |
| Fatigue | 4.93 | 1.54 |

Fmax for testing homogeneity of between subjects variances: 2.82

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between Subjects | | | | |
| Symptoms | 2 | 16.88 | 3.91 | .03 |
| Error | 37 | 4.32 | | |

Post-hoc tests for factor symptoms experienced during activity

| Level | Mean |
|---|---|
| No symptoms | 3.30 |
| Dyspnea | 5.30 |
| Fatigue | 4.93 |

Comparison Scheffe'

No symptoms < Dyspnea p=.05
No symptoms < Fatigue
Dyspnea > Fatigue

Table 9. Relationship between Self-efficacy expectations and symptoms experienced during Vitalog monitored physical activity

Self-efficacy expectation for walking

**Means and Standard Deviations**

| Variable | Mean | SD |
|---|---|---|
| No symptoms | 8.37 | 2.40 |
| Dyspnea | 7.25 | 2.76 |
| Fatigue | 7.70 | 2.63 |

Fmax for testing homogeneity of between subjects variances: 1.32

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between Subjects | | | | |
| Symptoms | 2 | 4.71 | .735 | ns |
| Error | 37 | 6.41 | | |

Self-efficacy expectation for general activity

**Means and Standard Deviations**

| Variable | Mean | SD |
|---|---|---|
| No symptoms | 9.68 | .64 |
| Dyspnea | 9.31 | .97 |
| Fatigue | 9.47 | .66 |

Fmax for testing homogeneity of between subjects variances: 2.33

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between Subjects | | | | |
| Symptoms | 2 | .51 | .933 | ns |
| Error | 37 | .54 | | |

### Self-efficacy expectation for health maintenance

**Means and Standard Deviations**

| Variable | Mean | SD |
|---|---|---|
| No symptoms | 9.67 | .67 |
| Dyspnea | 8.86 | 1.13 |
| Fatigue | 9.44 | 1.16 |

Fmax for testing homogeneity of between subjects variances: 3.00

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between subjects | | | | |
| Symptoms | 2 | 2.30 | 2.89 | ns |
| Error | 37 | .794 | | |

## Relationship between Self-Reported activity and symptoms experienced during Vitalog monitored physical activity

### Self-Reported activity for walking

**Means and Standard Deviations**

| Variable | Mean | SD |
|---|---|---|
| No symptoms | 8.43 | 3.79 |
| Dyspnea | 8.40 | 4.30 |
| Fatigue | 10.86 | 4.60 |

Fmax for testing homogeneity of between subjects variances: 1.47

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between subjects | | | | |
| Symptoms | 2 | 17.10 | 1.04 | ns |
| Error | 37 | 16.46 | | |

Self-Reported activity for general activity

## Means and Standard Deviations

| Variable | Mean | SD |
|---|---|---|
| No symptoms | 10.30 | 3.30 |
| Dyspnea | 9.10 | 2.13 |
| Fatigue | 11 | 2.77 |

Fmax for testing homogeneity of between subjects variances: 2.39

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between subjects | | | | |
| Symptoms | 2 | 8.30 | .943 | ns |
| Error | 37 | 8.80 | | |

Self-Reported activity for health maintenance

**Means and Standard Deviations**

| Variable | Mean | SD |
|---|---|---|
| No symptoms | 9.12 | .89 |
| Dyspnea | 8.36 | 1.35 |
| Fatigue | 9.62 | .46 |

Fmax for testing homogeneity of between subjects variances: 8.63

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between subjects | | | | |
| Symptoms | 2 | 3.59 | 3.78 | .03 |
| Error | 37 | .95 | | |

Post-hoc test for factor symptoms experienced during activity

| Level | Mean |
|---|---|
| No symptoms | 9.123 |
| Dyspnea | 8.355 |
| Fatigue | 9.620 |

Comparison Scheffe'

No symptoms > Dyspnea
No symptoms < Fatigue
Dyspnea < Fatigue p=.04

Of these, only ratings of perceived exertion during Vitalog monitored physical activity and self-reported health maintenance activity were shown to differ among groups. Individuals who did not experience symptoms during Vitalog monitored physical activity rated the particular activity as less strenuous than those who experienced dyspnea. Individuals with dyspnea reported lower health maintenance activity than those with fatigue.

Another aspect of Vitalog monitored physical activity of particular interest was the difference between the contribution of arm versus leg motion to heart rate response during physical activity (see Table 10). A multivariate analysis was performed and demonstrated that neither arm or leg motion contributed significantly to heart rate during Vitalog monitored physical activity. In addition, neither arm or leg motion were predictive of the perceived exertion of the activity.

Table 10. The relationship between heart rate during Vitalog monitored physical activity and arm and leg motion

| Source | df | Cum $R_2$ | $R_2$change | *F* | *p* |
|---|---|---|---|---|---|
| Arm motion | 1,37 | .01 | .01 | .35 | ns |
| Leg motion | 2,36 | .09 | .08 | 3.35 | ns |

The relationship between ratings of perceived exertion during Vitalog monitored physical activity and arm and leg motion

| Source | df | Cum $R_2$ | $R_2$change | *F* | *p* |
|---|---|---|---|---|---|
| Arm motion | 1,45 | .02 | .02 | 1.094 | ns |
| Leg motion | 2,44 | .03 | .00 | .218 | ns |

## Self-Efficacy Expectations

Self-efficacy expectation scales (SEES) and self-reported activity (SRA) checklists for walking, general activity and health maintenance were completed by each individual 24 hours prior to the exercise treadmill test (see Table 11). The alpha coefficients in this study for the self-efficacy expectation scale for walking was .92, for general activity was .84, and for health maintenance was .73. The alpha coefficient for the self-reported activity checklist for walking was .94, for general activity was .78, and for health maintenance was .54.

Table 11 displays the mean scores for this sample for the perceived self-efficacy expectation scale for walking 7.58 (+/- .27, range 2 to 14) for activity 9.53 (+/-.79, range 7 to 10), and for health maintenance 9.42 (+/-.91, range 6.88 to 10). The scores for self-reported activity were: walking 8.53 (+/-4.14, range 2 to 15), general activity 10.40 (+/-3.11, range 4 to 17), and health maintenance 9.02 (+/-1.04, range 6 to 10).

Table 11. Characteristics of perceived self-efficacy expectation and self-reported activity

| Characteristic | Mean | SD | Range | N |
|---|---|---|---|---|
| SEES walking | 7.58 | 2.7 | 2-14 | 47 |
| SEES activity | 9.53 | .79 | 7-10 | 47 |
| SEES health maintenance | 9.42 | .91 | 6.88-10 | 47 |
| SRA walking | 8.53 | 4.14 | 2-15 | 47 |
| SRA activity | 10.40 | 3.11 | 4-17 | 47 |
| SRA health maintenance | 9.02 | 1.04 | 6.00-10 | 47 |
| HR activity | 86 | 12 | 57-111 | 39 |
| HR rest | 77 | 13 | 54-113 | 39 |
| HR reserve activity | 9 | 12 | -9-45 | 39 |

The correlation between perceived self-efficacy expectation for walking and self-reported activity for walking was .50 (p=.00). The relationship between perceived self-efficacy expectation for general activity and self-reported general activity was .07 (p=ns). The correlation between perceived self-efficacy expectation for health maintenance and self-reported health maintenance was .56 (p=.00).

### Self-efficacy Expectations and Functional Capacity

The relationship between standard methods of functional assessment and self-efficacy expectations were examined. The NYHA functional class, Weber criteria and left ventricular ejection fraction were of primary interest. When perceived self-efficacy expectation was examined in relation to left ventricular ejection fraction, it was found that there was a positive correlation between left ventricular ejection fraction and perceived self-efficacy expectation for health maintenance (r=.29, p=.05). However, a negative correlation was found between left ventricular ejection fraction and self-reported general activity (r=-.36, p=.02) (see Table 13). All other relationships were low and did not reach statistical significance.

The relationships between self-efficacy expectations (SEES) and functional capacity as determined by NYHA functional criteria and Weber class are shown in Table 12. Correlations between New York Heart Association functional classification and SEES scores for walking yielded a negative association (r=-.33, p=.02) and for self-reported activity for walking (r=-.34, p=.02). Results for self-reported activity are included in Table 13. No differences were found among NYHA functional classes (I to III) for perceived self-efficacy expectation for walking, and general activity, self-reported general activity, and walking, heart rate during Vitalog monitored physical activity, and arm or leg motion.

Table 12. Relationship between exercise capacity and perceived self-efficacy expectation for walking, general activity and health maintenance

| | $\dot{V}O_2$max(kg) | AT% | HRmax | RQ | Extime | MaxMETS |
|---|---|---|---|---|---|---|
| SEES walking | | | | | | |
| | .34 | -.20 | .26 | .18 | .35 | .32 |
| | .02 | ns | ns | ns | .02 | .03 |
| SEES general activity | | | | | | |
| | .25 | -.16 | .11 | .06 | .22 | .23 |
| | ns | ns | ns | ns | ns | ns |
| SEES health maintenance | | | | | | |
| | .22 | .40 | .09 | .05 | .09 | .11 |
| | ns | .02 | ns | ns | ns | ns |

| | Weber class | HRres EX | RPP | NYHA FC | LVEF |
|---|---|---|---|---|---|
| SEES walking | | | | | |
| | -.32 | .35 | .45 | -.33 | .08 |
| | .03 | .03 | .00 | .02 | ns |
| SEES general activity | | | | | |
| | -.35 | .14 | .25 | -.06 | -.03 |
| | .02 | ns | ns | ns | ns |
| SEES health maintenance | | | | | |
| | -.33 | .27 | .34 | -.05 | .29 |
| | .02 | ns | .04 | ns | .05 |

Table 12 shows the Pearson product-moment correlations among the perceived self-efficacy expectations for walking, general activity, health maintenance and exercise capacity. The correlation coefficient between perceived self-efficacy expectation for walking (SEES walk), and maximal oxygen uptake, rate pressure product, exercise duration, Weber class and heart rate reserve during exercise were respectively: *r*= .33, *p*=.02; *r*=.45, *p*=.00; and *r*=.35, *p*=.02; *r*=-.32, *p*=.03 and *r*=.35, *p*=.03. Self-reported activity had a direct association with rate pressure product (*r*=.33, *p*=.04) as seen in Table 13. Perceived self-efficacy expectation for general activity and Weber class were inversely related (*r*=-.35, *p*-.02) as were both perceived self-efficacy expectation for health maintenance and percent of maximal oxygen uptake at which anaerobic threshold occurred (*r*=-.40, *p*=.02) and perceived self-efficacy expectation for health maintenance and Weber class (*r*=-.33, *p*=.02).

Table 13. Relationship between exercise capacity and perceived self-efficacy for walking, general activity and health maintenance

| | $\dot{V}$O2max | AT% | HRmax | RQ | EXtime | MaxMETS |
|---|---|---|---|---|---|---|
| SRA walking | | | | | | |
| | .08 | -.03 | .14 | -.03 | .23 | .22 |
| | ns | ns | ns | ns | ns | ns |
| SRA general activity | | | | | | |
| | -.12 | -.23 | .11 | -.03 | -.07 | -.07 |
| | ns | ns | ns | ns | ns | ns |
| SRA health maintenance | | | | | | |
| | .04 | -.18 | .12 | -.05 | .03 | .01 |
| | ns | ns | ns | ns | ns | ns |

| | Weber class | HRres EX | RPP | NYHA FC | LVEF |
|---|---|---|---|---|---|
| SRA walking | | | | | |
| | -.06 | .18 | .13 | -.35 | -.08 |
| | ns | ns | ns | ns | ns |
| SRA general activity | | | | | |
| | .05 | .00 | .33 | .09 | -.36 |
| | ns | ns | .04 | ns | .02 |
| SRA health maintenance | | | | | |
| | .01 | .30 | .06 | .21 | .02 |
| | ns | ns | ns | ns | ns |

## Relationship between functional assessment and exercise capacity

There was a direct relationship between left ventricular ejection fraction and exercise capacity as measured by maximum oxygen uptake ($r$=.29, $p$=.05) and respiratory quotient ($r$=.30, $p$=.04) (see Table 14). In contrast, a negative association was found between left ventricular ejection fraction and resting heart rate ($r$=-.42, $p$=.01).

Table 14. Relationship between exercise capacity and arm and leg motion and SEES

| HRact | Arm | Leg | SEESwalk | | SEESact | SEEShealth |
|---|---|---|---|---|---|---|
| max$\dot{V}O_2$ (kg/min) | .04 | -.03 | .14 | .30 | .22 | .18 |
| | ns | ns | ns | .04 | ns | ns |
| RQ | -.11 | -.03 | .07 | .18 | .06 | -.05 |
| | ns | ns | ns | ns | ns | ns |
| AT$\dot{V}O_2$ | .13 | -.15 | .09 | .11 | .04 | -.03 |
| | ns | ns | ns | ns | ns | ns |
| ATtime | .02 | -.01 | .27 | -.01 | .10 | -.02 |
| | ns | ns | ns | ns | ns | ns |
| AT% | -.15 | .04 | 0.14 | -.20 | -.16 | -.39 |
| | ns | ns | ns | ns | ns | .02 |
| ATHR | .43 | -.08 | -.19 | .05 | .09 | .05 |
| | ns | ns | ns | ns | ns | ns |
| ATRQ | -.30 | -.25 | -.00 | .10 | -.20 | .04 |
| | ns | ns | ns | ns | ns | ns |
| RPEAT | .18 | -.11 | .19 | .19 | .19 | .04 |
| | ns | ns | ns | ns | ns | ns |
| RPEmax | .06 | .04 | .17 | .25 | .12 | .24 |
| | ns | ns | ns | ns | ns | ns |
| HRrest | .53 | -.13 | -.16 | -.01 | .04 | -.29 |
| | .00 | ns | ns | ns | ns | ns |

| HRact | Arm | Leg | SEESwalk | | SEESact | SEEShealth |
|---|---|---|---|---|---|---|
| HRmax | | | | | | |
| | .61 | -.08 | -.08 | .26 | .11 | .09 |
| | .00 | ns | ns | ns | ns | ns |
| RPP | | | | | | |
| | .25 | -.06 | -.14 | .41 | .15 | .27 |
| | ns | ns | ns | .00 | ns | ns |
| MaxMETS | | | | | | |
| | .07 | .02 | .28 | .32 | .23 | .11 |
| | ns | ns | ns | ns | ns | ns |
| ExTime | | | | | | |
| | .09 | .02 | .28 | .35 | .22 | .09 |
| | ns | ns | ns | .02 | ns | ns |
| End symptom | | | | | | |
| | -.04 | -.07 | -.04 | .03 | -.02 | -.12 |
| | ns | ns | ns | ns | ns | ns |
| Weber Class | | | | | | |
| | .05 | .03 | -.19 | -.32 | -.35 | -.33 |
| | ns | ns | ns | .03 | .02 | .02 |
| LVEF | | | | | | |
| | -.31 | .10 | .09 | .08 | -.03 | .29 |
| | ns | ns | ns | ns | ns | .05 |
| NYHA FC | | | | | | |
| | .07 | -.05 | -.34 | -.33 | -.06 | .05 |
| | ns | ns | .02 | .02 | ns | ns |

| | LVEF | NYHA FC |
|---|---|---|
| max$\dot{V}O_2$ (kg/min) | .29 | -.05 |
| | .05 | ns |
| RQ | .30 | .22 |
| | .04 | ns |
| AT$\dot{V}O_2$ | .24 | -.22 |
| | ns | ns |
| ATtime | .21 | -.26 |
| | ns | ns |
| AT% | -.02 | -.33 |
| | ns | ns |
| ATHR | -.29 | .11 |
| | ns | ns |
| ATRQ | .26 | .03 |
| | ns | ns |
| RPEAT | -.18 | -.02 |
| | ns | ns |
| RPEmax | -.13 | -.10 |
| | ns | ns |
| HRrest | -.42 | .31 |
| | .01 | .05 |
| HRmax | -.28 | .21 |
| | ns | ns |
| RPP | -.06 | -.15 |
| | ns | ns |
| LVEF | ----- | -.16 |
| | | ns |

## NYHA functional classification

One method used to characterize the functional capacity of this sample was the NYHA functional classification criteria. Table 15 shows the relationship between NYHA functional class and exercise capacity. There is a moderate inverse relationship between NYHA functional class and percent of maximal oxygen uptake at which anaerobic threshold occurred ($\underline{r}$=-.33, $\underline{p}$=.05) and with systolic blood pressure ($\underline{r}$=-.35, $\underline{p}$=.02), all other variables have a low correlation with NYHA functional class. There was no difference among NYHA functional class in relation to left ventricular ejection fraction and maximal heart rate during exercise, maximal oxygen uptake, maximal metabolic equivalents, exercise duration and respiratory quotient (see Appendix 8). There was a difference among groups with respect to oxygen uptake at anaerobic threshold and the percent of maximal oxygen uptake at which anaerobic threshold occurred. Anaerobic threshold occurred at a lower oxygen uptake in those individuals considered class III than class II. The percent of oxygen uptake at which anaerobic threshold occurred is greater in those individuals considered class I than class II.

Another method of functional classification used in this study was the Weber criteria (see Table 15). When the Weber classification was examined in conjunction with exercise capacity, a negative relationship was found between Weber class and maximal oxygen uptake ($\underline{r}$=-.86, $\underline{p}$=.00), oxygen uptake at anaerobic threshold ($\underline{r}$=-.80, p=.00), the percent of oxygen uptake at which anaerobic threshold occurred (r=-.50, p=.00), the time at which anaerobic threshold occurred (r=-.60, p=.00) and the RQ at anaerobic threshold (r=-.40, p=.01). The moderate to high correlation between oxygen uptake and Weber class was expected as oxygen uptake was used to determine Weber class.

Table 15. Relationship between exercise capacity variables

|  | max$\dot{V}O_2$ (ml/kg) | RQ | AT$\dot{V}O_2$ | ATTime | AT% | ATHR | ATRQ |
|---|---|---|---|---|---|---|---|
| RPEAT | -.14 | .04 | -.17 | -.02 | -.09 | .30 | .17 |
|  | ns | ns | ns | ns | ns | ns | ns |
| RPEmax | .16 | .14 | -.00 | -.24 | -.37 | .05 | .14 |
|  | ns | ns | ns | ns | ns | ns | ns |
| HRrest | -.21 | -.07 | -.16 | -.26 | .06 | .65 | -.16 |
|  | ns | ns | ns | ns | ns | .00 | ns |
| HRmax | .39 | .00 | .38 | .20 | -.32 | .72 | -.17 |
|  | .01 | ns | ns | ns | ns | .00 | ns |
| RPP | .38 | .08 | .32 | .08 | -.21 | .29 | -.02 |
|  | .02 | ns | ns | ns | ns | .01 | ns |
| MaxMETS | .85 | .31 | .86 | .85 | -.30 | .03 | .08 |
|  | .00 | .03 | .00 | .00 | ns | ns | ns |
| ExTime | .84 | .31 | .87 | .86 | -.29 | .02 | .09 |
|  | .00 | .03 | .00 | .00 | ns | ns | ns |
| End symptom | .17 | -.04 | .27 | .40 | .17 | .04 | -.02 |
|  | ns | ns | ns | .02 | ns | ns | ns |
| Weber Class | -.86 | -.18 | -.80 | -.60 | .50 | -.04 | -.40 |
|  | .00 | ns | .00 | .00 | .00 | ns | .01 |

| | max$\dot{V}O_2$ | RQ | AT$\dot{V}O_2$ | ATtime | AT% | ATHR | ATRQ |
|---|---|---|---|---|---|---|---|
| **HRres EX** | | | | | | | |
| | -.62 | .05 | .58 | .44 | -.43 | .37 | -.08 |
| | .00 | ns | .00 | .02 | .02 | .05 | ns |
| **NYHA FC** | | | | | | | |
| | .05 | .22 | -.22 | -.26 | -.33 | .11 | .03 |
| | ns | ns | ns | ns | .05 | ns | ns |
| **LVEF** | | | | | | | |
| | .29 | .30 | .24 | .21 | -.02 | -.29 | .26 |
| | .05 | .04 | ns | ns | ns | ns | ns |

The previous sections have described the demographic characteristics, functional assessment, exercise capacity, activity level as per Vitalog monitor and perceived self-efficacy expectation for this particular sample. How these concepts interact can be better understood by examining their interrelationships by using correlational analysis and multivariate regression analysis which will be examined in the following sections.

To determine the difference between ratings of perceived exertion (RPE) at three different times (activity, anaerobic threshold and at maximal exercise), a repeated measures analysis of variance was performed (see Table 16). Not surprisingly, the RPE during maximal exercise was the highest, followed by RPE during submaximal exercise and then RPE during Vitalog monitored physical activity. The mean for RPE at anaerobic threshold was 3.77 or "moderate" (+/- 1.35). The mean for RPE during maximal exercise was 6.43 between "strong and very strong" (+/- 1.95) and that of RPE during Vitalog monitored physical activity was 3.77 "moderate to somewhat strong" (+/- 1.91).

In this sample there was a difference between ratings of perceived exertion at anaerobic threshold, Vitalog monitored physical activity and at maximal exercise ($F$=31.02, $p$<.00). A post-hoc analysis showed that RPE at anaerobic threshold and during Vitalog monitored physical activity were less than RPE at maximal exercise ($p$<.00, $p$<.00). The post-hoc analysis also demonstrated that RPE at anaerobic threshold and during Vitalog monitored activity were equal although not reaching statistical significance.

Table 16. Relationship between ratings of perceived exertion during activity, submaximal and maximal exercise

**Means and Standard Deviations**

| Variable | Mean | SD |
|---|---|---|
| RPE (anaerobic threshold) | 3.7714 | 1.3522 |
| RPE (maximal exercise) | 6.4286 | 1.9522 |
| RPE (activity) | 3.7714 | 1.9072 |

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Within Ss | | | | |
| RPE | 2 | 82.3714 | 31.02 | .00 |
| Error | 68 | 2.6557 | | |

Post-hoc tests for RPE

| Level | Mean |
|---|---|
| RPE (anaerobic threshold) | 3.771 |
| RPE (maximal exercise) | 6.429 |
| RPE (activity) | 3.771 |

Comparison Scheffe'

| | |
|---|---|
| RPE (anaerobic threshold) < RPE (maximal exercise) | p=.00 |
| RPE (anaerobic threshold) = RPE (activity) | |
| RPE (maximal exercise) > RPE (activity) | p=.00 |

To determine whether submaximal exercise better predicted Vitalog monitored physical activity levels, a series of multivariate analyses were performed, the results are included in Table 17. Oxygen uptake at anaerobic threshold and maximal exercise were the independent variables of interest, the dependent variables were heart rate during Vitalog monitored physical activity, arm and leg clicks. Multiple regression analyses were used to determine the relationship of the independent variables against each dependent variable of Vitalog monitored physical activity.

The dependent variable used for the first regression analysis was heart rate during Vitalog monitored physical activity. At step one, the correlation between oxygen uptake at anaerobic threshold and heart rate during Vitalog monitored physical activity was .0174 (*F*=.442, *p*=ns). At step two, oxygen uptake at maximal exercise was entered and the correlation coefficient between this variable and heart rate during Vitalog monitored physical activity was .018. The amount of variance explained was .0015 (*F*=.038, *p*=ns).

Table 17. Multiple Regression of submaximal versus maximal exercise with activity levels.

Heart Rate during activity

| Source | df | Cum $R^2$ | $R^2$change | *F* | *p* |
|---|---|---|---|---|---|
| $AT\dot{V}O_2$ | 1,26 | .0174 | .0174 | .442 | ns |
| max$\dot{V}O_2$ | 2,25 | .018 | .0015 | .038 | ns |

Arm motion during activity

| Source | df | Cum $R^2$ | $R^2$change | *F* | *p* |
|---|---|---|---|---|---|
| $AT\dot{V}O_2$ | 1,33 | .023 | .023 | .739 | ns |
| max$\dot{V}O_2$ | 1,32 | .024 | .002 | .053 | ns |

Leg motion during activity

| Source | df | Cum $R^2$ | $R^2$Change | *F* | *p* |
|---|---|---|---|---|---|
| $AT\dot{V}O_2$ | 1,33 | .008 | .008 | .27 | ns |
| max$\dot{V}O_2$ | 1,32 | .022 | .014 | .45 | ns |

A second multiple regression analysis was performed using leg clicks as the dependent variable, with no change in the independent variables. Step one in this regression analysis resulted in a correlation of .008 between oxygen uptake at anaerobic threshold and leg clicks (*F*=.27, *p*=ns). At the second step, using maximal oxygen uptake, the correlation coefficient was .022, and the explained variance was .014 (*F*=.45, *p*=ns).

In the last regression analysis performed, the dependent variable was arm clicks, again with no change in the independent variables. At step one, the relationship between oxygen uptake at anaerobic threshold and arm clicks was .023 (F=.739, p=ns). At step two, with oxygen uptake at maximal exercise entered, the correlation coefficient was .024 and the explained variance was .002 (F=.053, p=ns).

A series of multiple regression analyses were performed in order to determine which factor/s best predicted Vitalog monitored physical activity levels in this sample, results of which are included in Table 18. The independent variables were perceived self-efficacy expectation for walking, ratings of perceived exertion during Vitalog monitored physical activity, the percent of maximal oxygen uptake at which anaerobic threshold occurred, and maximal oxygen uptake. The regression analysis was limited to these variables because of the sample size.

Table 18. Predictors of Vitalog monitored physical activity levels

Heart Rate during Vitalog monitored physical activity

| Source | df | Cum $R^2$ | $R^2$change | F | p |
|---|---|---|---|---|---|
| SEES walking | 1,26 | .09 | .09 | 2.37 | ns |
| RPE activity | 2,25 | .09 | .00 | .01 | ns |
| AT percent | 3,24 | .10 | .01 | .23 | ns |
| max$\dot{V}O_2$ (ml/kg/min) | 4,23 | .10 | .00 | .00 | ns |

Arm Motion during Vitalog monitored physical activity

| Source | df | Cum $R^2$ | $R^2$change | F | p |
|---|---|---|---|---|---|
| SEES walking | 1,33 | .05 | .05 | 1.48 | ns |
| RPE activity | 2,32 | .05 | .00 | .04 | ns |
| AT percent | 3,31 | .06 | .01 | .29 | ns |
| max$\dot{V}O_2$ (ml/kg/min) | 4,30 | .06 | .00 | .01 | ns |

Leg motion during Vitalog monitored physical activity

| Source | df | Cum $R^2$ | $R^2$change | F | p |
|---|---|---|---|---|---|
| SEES walking | 1,33 | .02 | .02 | .65 | ns |
| RPE activity | 2,32 | .09 | .07 | 2.43 | ns |
| AT percent | 3,31 | .10 | .01 | .25 | ns |
| max$\dot{V}O_2$ (ml/kg/min) | 4,30 | .12 | .03 | .91 | ns |

The dependent variable for the first regression analysis was heart rate during Vitalog monitored physical activity. The correlation between perceived self-efficacy expectation for walking and heart rate during Vitalog monitored physical activity was .09, and the explained variance was .09, (F=2.37, p=ns). At step 2, ratings of perceived exertion during Vitalog monitored physical activity were entered and resulted in a correlation of .09. The variance explained by this factor was .00 (F=.01, p=ns). The percent of maximal oxygen uptake at which anaerobic threshold occurred, and maximal oxygen uptake did not contribute significantly to the model.

The second regression analysis was performed using arm clicks as the dependent variable against the identical independent variables and entered similarly to the above regression equation. At step one, perceived self-efficacy expectation for walking was entered and the correlation coefficient was .05 (F=1.48, p=ns). Ratings of perceived exertion were entered next and resulted in a correlation of .05. The amount of variance explained by perceived exertion was negligible .00, (F=.04, p=ns). The next variable entered into the regression equation was percent of maximal oxygen uptake at which anaerobic threshold occurred. For this step the correlation coefficient was .06, with .00 of the variance explained (F=.29, p=ns). The last variable was maximal oxygen uptake which resulted in a correlation of .06 and .00 of the variance explained (F=.01, p=ns).

The dependent variable of interest in the third regression analysis performed was leg clicks. Perceived self-efficacy expectation for walking was entered resulting in a correlation of .02, (F=.65, p=ns). Perceived exertion during Vitalog monitored physical activity was entered as the second variable and resulted in a correlation of .09, with .07 explained variance (F=2.43, p=ns). The third variable entered was percent of maximal oxygen uptake at which anaerobic threshold occurred, the correlation was .10, with an explained variance of .01 (F=.25, p=ns). The last variable of interest was maximal oxygen uptake which resulted in a correlation of .12, and .03 of the variance explained by this variable (F=.91, p=ns).

This chapter presented the pertinent findings of this study. Chapter 5 will discuss the limitations and possible rationale for these results.

# Chapter Five

# DISCUSSION

This chapter is intended to discuss the major findings of this study within the framework of its underlying conceptual model. Functional capacity, symptoms, physical activity and perceived self-efficacy will each be addressed in turn. The dicussion will focus then on the limitations, implications and significance of these results.

## Functional Capacity

### Functional Assessment and Exercise Capacity

In a recent study by Ziesche et al. (1990) the NYHA functional class was found to have a low, but statistically significant inverse relationship with maximal oxygen uptake. However, there was considerable variability in maximal oxygen uptake within each NYHA functional class such that class was not a sensitive predictor of peak exercise capacity. A similar variability of exercise capacity among the NYHA classes was observed in the current study.

As might have been expected the exercise capacity of subjects in NYHA class I was greater than the other 2 classes. Contrary to what would have been anticipated, individuals in class III demonstrated a greater exercise capacity than those in class II. These results may have been responsible for the lack of difference in exercise capacity found among the various NYHA functional classes.

Another possible contributing factor to this unexpected finding may have been inherent to the functional classification system itself. Because the NYHA functional classification criteria are based upon subjective assessment of physical activity, perceived limitations and reported activity tolerance may be biased. Activity tolerance may be affected by many factors, one of which is the individuals' expectation regarding his/her own level of physical activity. In order for the NYHA functional classification to be used effectively, the individual must be attentive to the distances walked or the number of steps they are able to climb which was difficult to quantitate for most subjects interviewed. Other factors which may have had an effect on the observed difference in exercise capacity among NYHA classes were the study subjects' age and gender as well as the sample size of each NYHA class.

Astrand and Rodahl (1986) have reported that both age and gender affect maximal oxygen uptake. In the current study sample, there were 4 women in class II and 2 in class III. Although unlikely, this gender difference may have accounted for the lower average maximal oxygen uptake observed in class II, because women have a lower maximal oxygen uptake than their age matched male counterparts.

The observed difference in maximal oxygen uptake more likely resulted from the unequal distribution of older subjects among the various NYHA classes. In this study, a significant difference in age was found among the NYHA classes ($p$=.04), with that difference occurring between individuals in class II and class III. As anticipated, individuals in class II were older than those in class III, which may have contributed to the observed lower maximal oxygen uptake.

The lack of difference in exercise capacity between NYHA functional class may also have resulted because of inadequate sample size. Although the total sample size met the criteria for a power of .80, a larger sample for each NYHA class may have provided adequate power to differentiate exercise capacity among classes.

Because of the apparent discrepancy between functional assessment using the NYHA functional criteria and exercise capacity, researchers have turned to other means of objectively assessing functional capacity. One alternative as suggested by Lipkin and colleagues (1985) is using submaximal exercise parameters to assess disease severity and as a marker of physical activity.

Results of the current study supported the use of anaerobic threshold as an index of disease severity as previously demonstrated by Itoh, Taniguchi, Koike, and Doi (1990) and Lipkin, Perrins, and Poole-Wilson (1985). These researchers found that individuals who reached anaerobic threshold earlier during exercise had greater severity of illness. In these subjects anaerobic threshold developed earlier during exercise, and was accompanied by a rise in lactate levels.

In the current study, anaerobic threshold occurred in association with higher maximal oxygen uptake and at a greater percentage of maximal oxygen uptake in individuals assessed as NYHA class II (.80) relative to those in class III (.68). There was a moderate, inverse relationship between NYHA functional class and submaximal exercise as determined by percent of maximal oxygen uptake at anaerobic threshold ($\underline{r}$ =-.33, $\underline{p}$ =.05). These results suggested that individuals considered NYHA class II developed respiratory acidosis later than those in class III, suggesting better physical conditioning in class II than III. However, submaximal exercise as determined by absolute values of oxygen uptake at anaerobic threshold did not correlate with NYHA functional class. Therefore, as no consistent relationship was found between disease severity and measures of submaximal exercise, the use of those exercise testing parameters as indicators of functional capacity and for assessment of disease severity should be examined more fully.

In addition to assessment of disease severity, Itoh, Taniguchi, and Doi (1990) suggest that anaerobic threshold could be used as an index of functional capacity in patients with congestive heart failure. That conclusion was not supported in the current study. The difference observed between the 2 studies may have been due to an assumption made by Itoh, Taniguchi, and Doi (1990) that, because anaerobic threshold was a measure of submaximal exercise, it accurately reflected functional capacity which was presumed to be submaximal in nature. Physical activity levels were not actually measured. Therefore, the conclusion that anaerobic threshold reflects physical activity level was not substantiated. The current study demonstrated that levels of physical activity were not predicted by measurement of submaximal exercise via anaerobic threshold.

One explanation for the inability of submaximal exercise to predict physical activity levels in the current study may have been that the intensity of physical activity was overestimated by the use of anaerobic threshold as an indicator of submaximal exercise. It could have been that physical activity was performed at a lower intensity than that required to stimulate anaerobic threshold. Perhaps if a lower percent of maximal oxygen uptake was examined in relation to physical activity, an association would have been found.

The reduction in sample size from 47 subjects to 35 subjects because of the undeterminable anaerobic threshold also may have contributed to the lack of predictive power of submaximal exercise. The inclusion of a greater number of individuals with measurable anaerobic threshold may have added sufficient power to the analysis to allow the prediction of physical activity from submaximal exercise.

The inherent difficulties of measuring anaerobic threshold requires further investigation and discussion. Anaerobic threshold although not dependent on subject motivation is dependent on effort. The lack of determinable anaerobic threshold could have been due to inadequate effort by the subjects during the exercise test. However, in the current study, subjects did display a maximal effort as confirmed by maximal exercise ratings of perceived exertion (6.45 "strong to very strong", (+/- 2, range 1 to 10), and respiratory quotient (1.04, +/-.12, range .79 to 1.42). Heart rate response to exercise was approximately 80% of maximal heart rate, calculated by the difference between 220 and the average age of the sample, 60 years. Therefore, heart rate response during exercise was adequate and effort was not the primary limitation to determining anaerobic threshold.

Lack of familiarity with respiratory gas equipment and face mask discomfort could theoretically have caused premature termination of exercise thereby obscuring a physiologic endpoint. However, face mask discomfort was not a reported problem as subjects gave other reasons for termination of exercise.

Another possibility which may have contributed to the lack of measurable anaerobic threshold was low reproducibility. Nine subjects were randomly selected to perform a second exercise treadmill test with respiratory gas analysis at their convenience, which resulted in a test-retest correlation of .82 (p =.01) for maximal oxygen uptake (ml/kg/min), .66 (p =.05) for respiratory quotient and .67 (ns) for oxygen uptake at anaerobic threshold. These results demonstrate the low reproducibility of submaximal exercise measurements particularly anaerobic threshold. By contrast, Itoh, Koike, Taniguchi, and Doi (1989) and Sullivan, Green, and Cobb (1990) have demonstrated that anaerobic threshold was a reliable and reproducible measure of submaximal exercise with a test-retest correlation respectively of .89 and .91. The difference in results between the 2 earlier studies and the current study may have resulted from the random selection of a small number of subjects to retest suggesting they were not representative of the population. Also the time delay between studies primarily because of laboratory scheduling difficulties which ranged from 2 weeks to 3 months may have affected reliability.

Another possible reason for the inability of submaximal exercise to predict physical activity was the method used to measure level of physical activity. The Vitalog monitor had been used primarily as a method to assure exercise compliance and to monitor exercise intensity by heart rate response. The Vitalog monitor had not been used to determine physical activity levels, especially low levels of physical activity as were performed by study subjects. Therefore, accuracy and sensitivity of the Vitalog in measuring low level physical activity was questionable and its use in this capacity requires further study.

While the use of submaximal exercise testing may have proved a poor predictor of physical activity in the current study, its utility is apparent as a possible substitute for maximal exercise testing. Submaximal exercise as measured by oxygen uptake at anaerobic threshold was found to be a good indicator of exercise capacity in the present study. There was a strong, direct relationship between submaximal exercise measurements, (oxygen uptake at anaerobic threshold) and maximal exercise measurements (maximal metabolic equivalents $\underline{r}$ =.86, $\underline{p}$ =.00, exercise duration $\underline{r}$ =.87, $\underline{p}$ =.00, heart rate reserve during exercise $\underline{r}$ =.57, $\underline{p}$ =.01) and a moderate association with maximal heart rate achieved during exercise ($\underline{r}$ =.38, $\underline{p}$ =.05). The strong relationship between submaximal and maximal exercise suggested that submaximal exercise testing parameters may have been used as an estimate of maximal exercise capacity without actually performing a maximal exercise test. An advantage of performing a submaximal exercise test is that it is less strenuous and more comfortable for the patient to perform. Therefore, patients are more apt to consent to undergoing a submaximal exercise test. However, the key to successful submaximal exercise testing is determination of anaerobic threshold which is not easily accomplished as discussed earlier in this section.

## Perceived Exertion

Perceived exertion of a particular physical activity may be a potential deterrent to its performance if that activity is considered to be too strenuous by the individual. Therefore, perceived exertion during daily physical activity and submaximal and maximal exercise were recorded and then compared. A difference was found among perceived exertion at submaximal and maximal exercise and Vitalog monitored physical activity. As expected, perceived exertion during submaximal exercise (3.77 "moderate to somewhat strong", +/- 2.42, range 4.48 to 8.38) and Vitalog monitored physical activity ( 3.77" moderate to somewhat strong", +/- 1.91, range 1.86 to 5.63) were less than that during maximal exercise (6.43 "strong to very strong", +/- 1.95, range 4.48 to 8.38). However, perceived exertion during submaximal exercise was equal to that during Vitalog monitored physical activity, although these results were not statistically significant.

These results suggested that subjects performed Vitalog monitored physical activity at a level which is generally recommended by clinicians to improve physical conditioning and exercise capacity (Pollock, Wilmore, & Fox, 1984) which in turn should have been reflected in a greater exercise capacity. However, physiologic determinants of exercise capacity of this sample did not indicate greater physical conditioning than would otherwise have been expected of individuals with congestive heart failure. Although not high enough to conclude that exercise capacity was affected by the level of performance of physical activity, the mean maximal oxygen uptake for this group was higher than that reported in the literature (Francis, Goldsmith, & Cohn, 1982). The mean maximal oxygen consumption for this sample was 16.76 ml/kg/min (+/- 6.45, range 7.4 to 40 ml/kg/min), slightly higher than that observed by Francis, Goldsmith, and Cohn (1982) which was 10.60 ml/kg/min. The difference observed in maximal oxygen uptake between these studies may be accounted for by the differences in severity of illness of the two study samples. Francis, Goldsmith, and Cohn (1982) examined 17 men with a mean age of 55, with NYHA class II to IV chronic congestive heart failure. The present study included subjects with a mean age of 60, with class I disease, but none with class IV. Therefore, although the exercise capacity of subjects in the current study was slightly greater than those reported by Francis, Goldsmith, and Cohn (1982), it was not significant enough to conclude that a conditioning effect was observed.

This conclusion was further supported by heart rate response during physical activity. Because ratings of perceived exertion are subjective, objective assessment also can be utilized to evaluate intensity of exercise or activity such as heart rate response. The mean heart rate response during physical activity was 86 BPM +/- 12 (range 57 to 111 BPM) which was approximately 54% of maximal heart rate achieved during exercise testing. The study included 8 individuals with atrial fibrillation. These subjects had a higher mean heart rate during physical activity of 92 BPM (+/-12, range 69 to 112 BPM) which was 63% of maximal heart rate during exercise. The atrial fibrillation group typically also had a higher heart rate for submaximal and maximal exercise. Because of the higher heart rate response to physical activity and exercise, these 8 individuals with atrial fibrillation were excluded from all analyses concerning heart rate response.

In the remaining subjects, heart rate during Vitalog monitored physical activity indicated that physical activity was sufficient to raise heart rate, but not enough to cause a training or conditioning effect. Typically, exercise to improve physical conditioning is prescribed at 70 - 80% maximal heart rate, which in this sample should have been approximately 112 BPM to 128 BPM. Therefore, although ratings of perceived exertion during Vitalog monitored physical activity and submaximal exercise suggested that activity was of sufficient intensity to produce a conditioning effect, the observed heart rate response was low and did not support any such conclusion.

In light of the foregoing discussion it must be noted that the relationship between heart rate during physical activity and ratings of perceived exertion has been questioned. Borg and Linderholm (1967, 1970) examined the relationship between heart rate during physical activity and ratings of perceived exertion in individuals with cardiac disease and found this relationship to be weak. The role of ratings of perceived exertion during physical activity in individuals with CHF has not been examined and requires further analysis. It is also important to consider that in the current study subjects were taking various cardiac medications which may have had an effect on heart rate response during physical activity and exercise performance. Therefore, these extraneous factors may have been responsible for masking the intensity of physical activity and / or exercise.

## Symptoms

The two primary symptoms experienced by people with congestive heart failure are dyspnea with exertion and fatigue (Parmley, 1989). Lipkin et al. (1986) found that symptoms which limit exercise in patients with CHF were dependent upon the type of exercise protocol used for testing. Dyspnea resulted if a "fast" protocol or one which terminated within 10 minutes was used, whereas fatigue occurred with the use of a "slow" protocol. The conclusions of Lipkin et al. (1986) were supported in the current study, as the primary reason for termination of exercise testing in 65% of subjects was fatigue using a "slow" protocol. For 22% of subjects, dyspnea was the sole reason for stopping exercise.

The intensity of the exercise test may have accounted for the type of symptoms experienced. However, the intensity and constant speed used in standard exercise protocols are not similar to performance of physical activity outside of a laboratory setting. In the "real" world, performance of physical activity consists of a variety of intensities and the use of more than one major muscle group. The differing intensities and use of various muscle groups may contribute to a particular symptom such as dyspnea versus fatigue. In addition, the individual has control of the intensity, speed, and duration of the activity, which can be altered temporarily if symptoms become bothersome. This control is not duplicated in the laboratory setting. Exercise is administered continuously until the individual decides to stop. Variation in speed, intensity and duration may represent strategies used by an individual to alleviate symptoms. Therefore, symptoms experienced in the laboratory setting may have no bearing on symptoms experienced in the "real" world. Because of the difference in intensity, speed and duration of the activity, symptoms may not be experienced by the individual, or symptoms may differ depending on the level of intensity of the activity performed.

## Symptoms and Physical Activity

When Vitalog monitored physical activity was examined, 49% of subjects stated that they had no symptoms during physical activity, 21% experienced dyspnea, 15% experienced fatigue and 15% sore muscles/joints. A comparison of the symptoms experienced during Vitalog monitored physical activity and exercise revealed that 42% experienced dyspnea and 40% experienced fatigue during both periods. These results pointed out a difference in the symptoms individuals experience during exercise and physical activity and the lack of overlap between the laboratory setting and daily physical activity. The most striking difference was that 49% of individuals experienced no symptoms during Vitalog monitored physical activity suggesting self-limitation of activity.

The difference in symptoms experienced may be attributable to the types of physical activity performed during Vitalog monitoring. These included walking on a flat surface (49%), general activity (40%), such as housework and yardwork, recreational type activity (9%), lifting boxes (2%), and walking uphill (2%). Although walking was the most frequently cited physical activity, there could have been a large variability in energy consumption during walking, so that it could not be assumed that walking was of sufficient intensity to elicit symptoms in all subjects. This variability of intensity could also have been applied to general activity.

One method which can be used to assess the intensity of physical activity is perceived exertion. Ratings of perceived exertion were lower during Vitalog monitored physical activity (4 +/- 1, range 3 to 5) than during maximal exercise (6 +/- 2, range 4 to 8). This supports the hypothesis that the level of Vitalog monitored physical activity the individual performed was not sufficient to induce symptoms.

The lack of symptoms suggested that individuals may have regulated the intensity, duration or speed of physical activity to minimize symptoms they experienced. Alternatively, the lack of symptoms suggested that individuals did not engage in any routine moderate to high intensity physical activity, such as vigorous walking or running. The lack of vigorous physical activity was demonstrated by the heart rate response during activity which was only 54% of calculated maximum heart rate. Only 3 individuals exercised regularly. One performed vigorous walking, and the other 2 participated in a cardiac rehabilitation program 3 times per week and walked 2-3 times per week. Because only 3 subjects participated in a regular exercise program the supposition that the subjects of this current study did not engage in vigorous exercise was strengthened.

Another possible explanation for the lack of symptoms during Vitalog monitored physical activity was that most individuals in this sample may have mastered symptom management, although the time necessary for acquisition of this skill is unknown. All subjects had at least one bout of CHF of at least 3 months, with a mean diagnosis of chronic CHF of 1.5 years (range 1 to 7 years). Therefore, in this study sample, there were no newly diagnosed (<1 year) individuals. Individuals who experienced symptoms during Vitalog monitored physical activity could have been "novices" or individuals who had not developed effective symptom management skills.

Alternatively the appearance of symptoms may have reflected the greater intensity or duration of physical activity performed by some individuals rather than a greater severity of illness. Therefore, symptoms experienced during physical activity may not necessarily be indicative of disease severity, but may instead have reflected how comfortable an individual felt about performing physical activity which resulted in his/her experiencing symptoms and how willing the individual was to be active to the point of experiencing symptoms. On the other hand, it may have been a reflection of the level of skill the subject had in symptom regulation during physical activity, or in some cases symptoms may in fact have been a psycho-physiologic marker of disease severity. This area requires further investigation.

## Symptoms and Perceived Exertion Ratings During Physical Activity

To further clarify the factors which may have contributed to symptoms during physical activity, ratings of perceived exertion during Vitalog monitored physical activity and the type of physical activity performed were considered. Perceived exertion was compared among individuals who did not experience symptoms and those who experienced dyspnea or fatigue. Those who complained of dyspnea had a higher rating of perceived exertion (5.30 "strong", +/- 2.58, range 2.72 to 7.88) than those with fatigue (4.93 "somewhat strong to strong", +/- 1.54, range 3.39 to 6.47) and those with no symptoms (3.30 "moderate", +/- 1.97, range 1.33 to 5.27). Reported Vitalog monitored physical activity for individuals who reported dyspnea were walking on a flat surface (70%), general activity (20%) and recreational activity (10%). Individuals with no reported symptoms engaged in physical activity consisting of general activity (52%) recreational (13%) and lifting boxes (4%).

Subjects who experienced fatigue also had a greater rating of perceived exertion than those with no symptoms. The physical activity of this subgroup consisted of walking on a flat surface (86%) and general activity (14%). These findings strengthened the theory that individuals who experience symptoms during physical activity perform more strenuous levels of activity as evidenced by increasing ratings of perceived exertion scores. These individuals may have also felt more comfortable with experiencing symptoms than those who did not. Alternatively increased symptoms may have contributed to increased perceived exertion of a particular activity.

## Symptoms and Exercise Capacity

Upon examination of the exercise capacity data, there appeared to be a contradiction in findings with respect to exercise capacity of individuals who had no symptoms versus those who experienced symptoms. Exercise capacity was measured by maximal oxygen uptake and submaximal exercise capacity was measured by oxygen uptake at anaerobic threshold and percent of maximal oxygen uptake at anaerobic threshold. The submaximal exercise data implied that individuals who had no symptoms during physical activity had greater disease severity than individuals with dyspnea or fatigue. Intuitively, one would have expected individuals with no symptoms to be "healthier" than those individuals who had experienced symptoms during physical activity. On the other hand, the exercise capacity data as determined by maximal oxygen uptake, are not consistent with the submaximal exercise capacity data and indicated that individuals who had greater exercise capacity had a lesser disease severity.

Individuals who had no symptoms during physical activity had a lesser submaximal exercise capacity (as measured by percent of maximal oxygen uptake at which anaerobic threshold occurs) (.71) as compared to individuals who experienced dyspnea (.83) or fatigue

(.72). This trend differed from that observed with oxygen uptake at anaerobic threshold. The oxygen uptake at anaerobic threshold for individuals who had no symptoms was 13.54 ml/kg/min (+/- 4.74, range 8.80 to 18.28 ml/kg/min), dyspnea 14.54 ml/kg/min (+/-3.28, range 11.26 to 17.82 ml/kg/min) and fatigue 10.40 ml/kg/min (+/-2.40, range 7.92 to 12.8 ml/kg/min). According to the results of the absolute values of oxygen uptake at anaerobic threshold, individuals who had fatigue developed anaerobic threshold earlier, indicating a greater severity of disease than those who had no symptoms and those who had dyspnea. These results indicated that although submaximal exercise capacity was an objective measure, it may not have been a reliable indicator of disease severity and was dependent upon the measurement of anaerobic threshold used. Therefore, the use of submaximal exercise, specifically anaerobic threshold, as an indicator of disease severity must be done with caution.

An alternative method of objective assessment of functional assessment is the Weber criteria. Using the Weber classification criteria, 35% of individuals with no symptoms were class a, 22% were class b, and 44% were class c. According to these data, a majority of individuals with no symptoms had maximal oxygen uptake of 10 to 15 ml/kg/min (class c), followed by those with a maximal oxygen uptake of greater than 20 ml/kg/min (class a) and finally those who were class b had a maximal oxygen uptake of 15 to 20 ml/kg/min. Based upon the Weber criteria, it was difficult to determine the classification of individuals who did not experience symptoms during physical activity. However, according to the data, individuals with a lower maximal oxygen uptake experienced symptoms more easily during physical activity than individuals with a higher maximal oxygen uptake. Of those individuals who experienced dyspnea, 10% were considered class A, 40% class B, and 40% class C. Fourteen percent of individuals with fatigue were class A, followed by 0% class B and 71% class C.

Contrary to the Weber classification criteria, maximal oxygen uptake was highest in those with no symptoms (18.92 ml/kg/min, +/- 7.49, range 11.43 to 26.41 ml/kg/min), followed by those with dyspnea (15.74 ml/kg/min, +/- 5.09, range 10.65 to 20.83 ml/kg/min) and finally those with fatigue (13.76 ml/kg/min, +/- 4.88, range 8.88 to 18.64 ml/kg/min). These results indicated that as expected, individuals with no symptoms had a greater exercise capacity than those with dyspnea or fatigue. Therefore, symptoms were indicative of a lesser exercise capacity and greater disease severity. The discordance in submaximal exercise measures may have been a result of a disproportionate distribution of individuals with measurable anaerobic threshold. Maximal oxygen uptake was not affected because all 47 subjects completed the exercise test and consequently had a maximal oxygen uptake. But, anaerobic threshold was not determinable in 12 individuals. It was possible that more individuals with symptoms of dyspnea and fatigue than those with no symptoms had undeterminable anaerobic threshold, thus skewing the results.

The difference observed between Weber class and absolute values of maximal oxygen uptake may have been due to a loss of data in converting numerical data such as absolute values of maximal oxygen uptake into categorical data such as the Weber class (Cohen, 1988). Therefore, when absolute numbers are available these should be used.

### Symptoms and Functional Assessment- NYHA

There was a discordance between reported limitations of physical activity due to symptoms (NYHA functional class) and symptoms reported during Vitalog monitored physical activity. Individuals with no symptoms were not considered class I as would have been expected, but a majority were class II and III. Individuals with dyspnea were considered class I (40%) or II (40%) or class III (20%) and those with fatigue were similarly distributed in class I and II (29% each) with 43% in class III. The distribution of subjects among classes was of concern, because according to the NYHA functional criteria, individuals with no symptoms during physical activity should have been considered class I. The discrepancy may have reflected the inaccuracy of the NYHA functional classification criteria or perhaps the variability of the assessment made by clinicians to determine functional class or a difference in subjects' definition of signs and symptoms.

It was also possible that during the interview for the NYHA functional class, maximal capacity as an index for symptomatology was determined rather than which was normally performed. Therefore, patients conveyed what they had perceived as their upper most limit which may not have been accurate in that it may not have been performed on a regular basis. Therefore, the discrepancy between Vitalog monitored physical activity and NYHA functional criteria may have resulted from the difference between what an individual actually performed on a daily basis and their maximal capacity.

Physical inactivity during the period the Vitalog monitor was worn may also have contributed to this discrepancy. Subjects, however, stated that the level of physical activity performed during the Vitalog monitoring period was typical of their normal routine. In either case, these results demonstrated the inherent difficulties of an accurate assessment of physical activity based upon the NYHA functional criteria.

What is needed is a better system of assessment which combines both objective data such as maximal oxygen uptake and subjective assessment of symptoms, since it is difficult to determine functional capacity based on only one of these. When the NYHA functional criteria and Weber class for this study sample were compared no association was found.

## Self-Efficacy Expectation

A moderate inverse relationship was found between NYHA functional criteria and the scores on self-efficacy expectation scale (SEES) for walking ($\underline{r}$ =-.34, $\underline{p}$ =.02), implying that an individual considered to have a better NYHA functional classification (lower scores) had higher self-efficacy. However, when scores among classes were compared, there were no statistically significant differences. Because self-efficacy expectation for walking was the only scale to have an association with NYHA functional criteria, it is possible that self-efficacy for walking may have been a good marker for functional capacity assessment. A study conducted by Allen, Becker, and Swank (1990) examined factors related to recovery from coronary bypass graft (CABG) surgery. These researchers found that self-efficacy beliefs were significant predictors of functional status outcomes defined as household physical activity at 6 months post CABG surgery. However, disease severity, functional capacity, comorbidity or preoperative functioning were not predictive of functional outcomes. In addition, postoperative exercise treadmill performance contributed to a small, but significant amount of explained variance.

The relationship between Weber class and self-efficacy expectation and self-reported activity for walking, general activity and health maintenance were moderate and negative. These results implied that as Weber class increased from class a to class d, self-efficacy expectation and self-reported activity decreased. Therefore, the self-efficacy expectation and self-reported activity checklists may have been good indicators or markers of functional capacity. When the relationship between self-efficacy and Weber class was examined further a difference was found between Weber class for self-efficacy beliefs for health maintenance, suggesting that self-efficacy beliefs for health maintenance may be differentiated by Weber class. Interestingly, the mean scores for health maintenance were variable and no distinct pattern was discernible.

No differences among Weber classes were found for self-efficacy beliefs and self-reported activity for walking, and general activity. However, this finding implied that although subjects were in different Weber classes, self-efficacy beliefs and self-reported activity for walking and general activity for these groups were not different.

## Self-Efficacy Expectation and Exercise Capacity

Another means of assessing functional capacity, exercise capacity, was examined to determine the degree of association with self-efficacy expectation for walking, general activity and health maintenance. Perceived self-efficacy for walking had a direct, moderate correlation with maximal oxygen uptake ($\underline{r}$ =.30, $\underline{p}$ =.02), rate pressure product ($\underline{r}$ =.45, $\underline{p}$ =.00) and exercise duration ($\underline{r}$ =.35, $\underline{p}$ =.02). These findings suggested that as self-efficacy beliefs for walking increased so did maximal oxygen uptake, rate pressure product and exercise duration. Therefore, it can be inferred that if an impact can be made on either self-efficacy beliefs for walking, maximal oxygen uptake, rate pressure product or exercise duration, the associated variable will move in the same direction. Ewart et al. (1983) demonstrated that efficacy expectation for walking was enhanced by treadmill exercise which translated to other similar types of physical activity when reinforced by physician or nurse counseling. More recently Gortner and Jenkins (1990) reported that perceived self-efficacy for walking was enhanced in individuals who were given the experimental treatment consisting of telephone contact and education. In addition, self-reported activity for general activities were increased in the experimental group at 4 and 8 weeks post cardiac surgery. New York Heart Association functional class at 4 and 8 weeks significantly predicted self-reported activity performed at 12 weeks, and NYHA functional class determined at 8 weeks significantly predicted self-reported activity at 24 weeks. These findings suggested that in patients post cardiac surgery, self-efficacy expectations could have been influenced by interventions such as coaching and education and these interventions could have had a positive impact on general activity performance.

### Self-Efficacy Expectation and Vitalog Monitored Physical Activity

No relationship was found between self-efficacy expectation and self-reported activity scores for walking, general activity, health maintenance and Vitalog monitored physical activity, consisting of heart rate, heart rate reserve and arm and leg motion. A moderate association between self-reported activity for walking and leg motion was found ($r$=.37, $p$=.03). The apparent lack of association between self-efficacy expectation and self-reported activity for walking, general activity and health maintenance with Vitalog monitored physical activity may have been a result of poor Vitalog instrument validity and reliability.

## Self-Effiacy Expectation and Symptoms

No association was found between self-efficacy expectation for general activity and health maintenance and symptoms experienced during Vitalog monitored physical activity. A moderate reciprocal correlation was observed between self-efficacy expectation for walking and symptoms experienced during Vitalog monitored physical activity ($\underline{r}$ =-.37, $\underline{p}$ =.01). This correlation suggested that as symptoms experienced during Vitalog monitored physical activity diminished, self-efficacy for walking increased. The lack of symptoms experienced during walking contributed to greater efficacy beliefs for walking. The greater belief for walking enhanced performance of walking.

Self-reported activity for health maintenance was the only factor which was found to be different among groups of individuals with dyspnea, fatigue and no symptoms during exercise testing. The primary difference occurred between the dyspnea and fatigue groups, with self-reported activity for health maintenance greater in the fatigue than dyspnea group.

Perceived self-efficacy expectation and self-reported activity for walking, general activity and health maintenance were examined in relation to the various symptoms experienced during Vitalog monitored physical activity. No differences were found among individuals who reported no symptoms, dyspnea or fatigue during Vitalog monitored physical activity. A discrepancy was found between perceived self-efficacy expectation and self-reported activity. For example, the mean value of perceived self-efficacy expectation for walking was 8.37 (+/- 2.34, range 6.03 to 10.71) for individuals with no symptoms during activity, 7.25 (+/- 2.76, range 4.49 to 10.01) for those with dyspnea, and 7.70 ( +/- 2.63, range 5.07 to 9.63) for those with fatigue. Self-reported activity for walking for those with fatigue was 10.86 (+/- 4.60, range 6.26 to 15.46), 8.43 (+/- 3.79, range 4.64 to 12.22) for those with no symptoms and 8.40 (+/- 4.30, range 4.1 to 12.7) for those with dyspnea.

All subjects had lower perceived self-efficacy expectations than self-reported activity scores. These results implied that subjects performed at a greater level than they believed they could. An individual may have been more active prior to becoming ill and therefore, the individual expected more of themself. Although activity levels may have been lower than before the individual became ill, the individual perceived activity levels to be lower than they actually were. The discrepancy may have also been attributed to a general lack of confidence because of anticipated symptom limitation.

Individuals with no symptoms during Vitalog monitored physical activity had the highest perceived self-efficacy expectation scores followed by those who experienced dyspnea and then those with fatigue. Self-reported activity differed slightly in individuals who experienced fatigue versus dyspnea and no symptoms. Individuals who experienced fatigue reported the highest level of self-reported activity, followed by individuals with no symptoms and lastly those with dyspnea. The difference in scores may have been a limitation of the instrument used for self-reported activity which only measured the physical activity performed within the past 24 hours and therefore information regarding walking or general activity habits may have been missed because of the small window of time assessed. Although most subjects stated that the Vitalog monitored physical activity period reflected their normal routine, a few individuals stated that the self-reported activity checklist did not fully capture their physical activity because of the period of time assessed. They had not performed a particular activity within the past 24 hours; therefore, more vigorous physical activity may have been performed but not on a daily basis. Perhaps the self-reported activity checklist would have been a better indicator of physical activity if the window assessed included a longer time period for example, 48 hours instead of 24 hours. However, this result may have also reflected the difference in self-efficacy expectation and actual physical activity performed between individuals who exerted themselves to the point of experiencing fatigue versus those who limited physical activity to levels which did not induce symptoms.

## Predictors of Activity Levels

An hypothesis of this study was that physiologic and psychologic predictors of physical activity levels would be found. Perceived self-efficacy expectation for walking, ratings of perceived exertion during Vitalog monitored physical activity, percent of oxygen uptake at anaerobic threshold and maximal oxygen uptake did not predict physical activity levels of individuals with congestive heart failure. Physical activity levels were defined in terms of heart rate response during physical activity, as well as arm and leg motion.

One problem with the data that may have contributed to this lack of findings may have resulted because of the lack of measurable anaerobic threshold in this sample which served to reduce the sample size. These individuals were eliminated from the analyses using anaerobic threshold, possibly preventing a discernible effect from reaching significance. Along these same lines, individuals with atrial fibrillation also had to be dropped for the heart rate analyses portion which also reduced the sample size and in the case of anaerobic threshold compounded the reduction in sample size.

The primary concern, however, was the instrument used for physical activity monitoring. As stated earlier, the Vitalog monitor had been used to validate exercise bouts rather than as a measure of activity level, and may not have reflected true levels of physical activity. Another limitation of the Vitalog monitored physical activity was that only a small circumscribed time period was selected for analysis. The period selected was the most strenuous Vitalog monitored physical activity which was validated by the heart rate response and arm and leg movement was analyzed. This period was selected because it should have reflected the highest intensity physical activity performed during Vitalog monitoring and therefore provided the maximal heart rate response and movement by the arms and legs. The possibility remains, however, that this data may not have reflected a subject's average or overall physical activity. It also is theoretically possible that although the psychologic and physiologic variables selected reflected functional capacity, they were not predictive of physical activity level and perhaps other variables or combination of variables may have provided a better predictive model.

## Significance

Congestive heart failure is a chronic, debilitating illness with a high mortality rate. Treatment and assessment of this disease process is based upon an individual's ability to perform physical activity which may/may not be limited by symptoms. Although it is assumed that these individuals are not physically active, this area has not been fully explored. This study described the performance of physical activity of individuals with CHF by examining the relationship among psychologic and physiologic factors that may have affected the physical activity of these patients. These individuals may have been capable of performing greater levels of physical activity on a daily basis then they actually performed, which in this study was less than their exercise capacity would have predicted. This discrepancy between exercise capacity and physical activity raised the possibility that lack of knowledge regarding what their capabilities were, lack of motivation, fear or avoidance of experiencing symptoms all may have contributed to limit physical activity. A better understanding of the factors which prevents individuals from achieving greater levels of physical activity should be sought so that activity levels can improve to meet exercise capabilities.

Questions were raised regarding the method of assessing functional capacity in individuals with CHF, either by interview such as the NYHA functional criteria or by exercise testing. An inconsistent relationship was found between NYHA functional class and exercise capacity and physical activity in this study, suggesting that the NYHA functional criteria did not adequately measure physical activity. One must be aware of whether the NYHA functional class was assessing actual performance levels of physical activity or capacity for physical activity, as they may have differed.

Maximal exercise or submaximal exercise measurements also did not reflect physical activity levels as determined by the Vitalog monitor. These results suggested that exercise capacity and physical activity may have been very different concepts and measuring exercise capacity did not necessarily reflect an individual's actual performance level. In fact, a gap was shown to exist between these 2 concepts, underscoring the fact that the assumption that improving exercise capacity is reflected in a greater level of physical activity is not necessarily true.

This study demonstrated that physical activity was indeed minimal and consisted to a largely of general activities such as housecleaning, yardwork, and walking on a flat surface. These activities did not provide enough physical stimuli to improve exercise capacity as they raised heart rate to approximately 54% of its exercise maximum, with mean ratings of perceived exertion of 4 (+/-2, range .5 to 10). The lack of vigorous physical activity again underscored the discordance between the level of activity actually performed and exercise capacity.

During the initial interview, individuals in this study were asked if they were given guidelines for exercise or physical activity levels, and only 3 subjects responded positively. All others stated they were told to do what they could and consequently did not perform any regular physical activity or exercise.

Data from this study showed that individuals with CHF did not regularly perform physical activity to their maximum capacity. Because of the discrepancy between capability and actual performance levels exercise prescriptions appropriate to the actual level of physical activity performance may have been of benefit for this group. Exercise prescriptions may in turn have helped to improve their level of daily physical activity. Small improvements in physical activity levels for this group may have had tremendous impact on their lives because their level of activity is so low (Williams, 1985). Squires et al. (1987) have demonstrated that exercise training was beneficial in improving exercise capacity. However, no studies have examined the impact of exercise training and improved exercise capacity on daily level of physical activity. The above argument makes clear the need for future research in this area.

Studies have been performed that examined the effect of self-efficacy beliefs on actual performance (Allen, Becker, & Swank, 1990; Gortner & Jenkins, 1990). Both of these studies demonstrated that improved self-efficacy enhanced activity levels. This area appears fruitful and may require further investigation with individuals with congestive heart failure.

The role of symptom management also was alluded to in this study. Symptoms such as dyspnea and fatigue are typically thought of as indicators of disease severity. However, it may have been that the appearance of symptoms reflected the individual's inability to effectively cope with symptoms, especially during physical activity. Another possibility is that the manifestation of symptoms may have suggested an individual's willingness to engage in physical activity of sufficient intensity to produce symptoms and his/her ease in dealing with those symptoms.

Although there were difficulties with the Vitalog monitor, the current study attempted to quantitate physical activity of individuals with congestive heart failure by heart rate response to physical activity and arm and leg motion. It appeared that heart rate response to physical activity and exercise in this population was not an appropriate index of physical activity and other methods to quantitate physical activity should be explored.

The results of the current study complemented the current body of knowledge by describing the level of physical activity which individuals with CHF were capable of performing and by examining the possible role of symptoms in limiting physical activity. These results added to the existing literature which examined the use of subjective methods of assessing functional capacity and its relationship to more objective means, such as exercise testing. In addition, the current study added the unique dimension of quantitating physical activity of individuals with congestive heart failure. Although the current study did not demonstrate any predictors of physical activity levels in individuals with CHF, it represented a good beginning for further exploration of this area.

# Chapter 6

## SUMMARY AND CONCLUSIONS

The purpose of this study was to determine psychologic and physiologic predictors of physical activity levels of patients with congestive heart failure. Specific variables examined included: 1) anaerobic threshold, a measure of submaximal exercise; 2) maximal oxygen uptake, a measure of maximal exercise capacity; 3) self-efficacy expectation for walking, general activity, and health maintenance, and 4) perceived exertion during Vitalog monitored physical activity, submaximal and maximal exercise. Briefly, subjects were asked to perform a symptom-limited exercise test using the modified Naughton protocol with respiratory gas analysis. Subjects were also asked to wear a Vitalog activity monitor no sooner than 24 hours after the completion of, or prior to, the exercise test. In addition, subjects kept a log of the most strenuous physical activity they performed while wearing the Vitalog monitor, which included the time, type and duration of the activity performed, the perceived exertion and any symptoms which were experienced during the activity. Subjects also completed a Jenkins Self-Efficacy Expectation questionnaire 24 hours prior to the exercise test.

The study sample consisted of 47 subjects between the age of 33 to 91 (mean 60). Subjects were mostly retired (68%), white (57%) males, with various etiologies of congestive heart failure. The most common was coronary artery disease/myocardial infarction, followed by various types of cardiomyopathy. Other less common etiologies for CHF included hypertension, rheumatic heart disease and valvular disease. The model subject was taking digoxin, diuretics and ace inhibitors most commonly. The mean left ventricular ejection fraction for this sample was 32 (+/- 12, range 14 to 57). According to the NYHA functional classification a majority of the subjects were considered class II (45%) followed by class I (32%) and finally class III (23%). There were no subjects rated as class IV in this study. When these subjects were classified according to the Weber criteria, it was found that a majority were class C (51%), while 23% were class B, 21% were class A and only 4% were class D.

The exercise capacity was lower than normal as demonstrated by maximal oxygen consumption of 16.76 ml/kg/min (+/-6.45, range 7.4 to 40 ml/kg/min), maximal metabolic equivalent of 4 (+/-2, range 1 to 11) and exercise duration of 13.56 minutes (+/- 6.33, range 1.5 to 33 minutes) using the modified Naughton protocol.

Self-efficacy beliefs and self-reported activity were examined as potential predictors and moderators of physical activity levels. When perceived self-efficacy expectation was examined it was found that the mean score for perceived self-efficacy expectation for walking was 7.58 (+/-2.7, range 2 to 14), for general activity was 9.53 (+/-.79 to range 7 to 10) and for health maintenance 9.42 (+/-.91, range 6.88 to 10). These scores are lower than would be expected for healthy individuals. Self-reported activity scores for walking were 8.53 (+/-4.14, range 2 to 15), general activity 10.40 (+/-3.11, range 4 to 17) and 9.02 (+/-1.04, range 6.13 to 10) for health maintenance.

The relationships between self-efficacy expectations (walking, general activity and health maintenance) and functional capacity, and Vitalog monitored physical activity were examined using the Pearson product moment correlation coefficient. There was a direct moderate association between self-efficacy expectation for walking and exercise capacity as measured by maximal oxygen uptake, rate pressure product and exercise duration. A moderate inverse relationship was demonstrated between self-efficacy expectations for walking and general activity and self-reported walking, and NYHA functional criteria. No difference in self-efficacy expectation for walking or activity was noted between NYHA classes. The relationship between Weber class and self-efficacy expectation for walking, general activity and health maintenance was moderate and reciprocal. Only self-efficacy expectation for health maintenance was observed to differ between Weber classes.

The specific Vitalog monitored physical activity reported by subjects consisted of walking on flat surface (47%), general household activity (40%), recreational activity (9%), lifting boxes (2%) and walking uphill (2%). Vitalog monitored physical activity levels were characterized as a mean of 13 (+/- 24, range 0 to 104) leg clicks, 29 (+/-25, range 0 to 104) arm clicks, and an average heart rate of 86 BPM (+/-12, range 57 to 111 BPM) during physical activity. The mean rating of perceived exertion was 4 (+/-2, range .5 to 10). A majority of subjects (49%) reported no symptoms during Vitalog monitored physical activity, others reported dyspnea (21%), fatigue (15%) and sore muscles/joints (15%). Almost an equal number of subjects experienced identical symptoms (dyspnea 42%, fatigue 43%) during both exercise testing and Vitalog monitored physical activity. When the ratings of perceived exertion for the 3 primary symptom groups (no symptoms, dyspnea, and fatigue) were examined, it was found that those who did not report symptoms considered the activity less strenuous (had a lesser ratings of perceived exertion score) than those who experienced dyspnea. In this study, the selected psychologic and physiologic variables were not predictive of Vitalog monitored physical activity.

## Limitations

Several limitations of this study have already been noted. Additional limitations are brought forth in the following section.

Characteristics of the study sample pose limitations to generalizability of the current study. Individuals were recruited from a large teaching institution in San Francisco and were primarily male, compromising the generalizability of the findings to the larger population with congestive heart failure. Another aspect of the sample was the large number of retired persons, which may have affected the level of physical activity. Perhaps if a greater number of working persons were included in the sample, the physical activity level would have been higher.

A threat to statistical conclusion validity is the small sample size which may affect power. Although initially sufficient for adequate power, the sample size was reduced from 47 subjects to 35 subjects because of the lack of determinable anaerobic threshold in several individuals. It would have been advantageous to have a larger sample of individuals who had determinable anaerobic threshold. However, the lack of measurable anaerobic threshold is an important finding because there is controversy as to the utility of this measure in assessing levels of physical activity. Itoh et al. (1990) consider this measure a reliable and valid means of assessing physical activity. However, if anaerobic threshold is not determinable in a large percentage of patients, its clinical utility must be questioned. Sample size was compromised further by elimination of subjects with atrial fibrillation from heart rate analyses.

Although the intent of the study was to obtain a broad cross section of subjects with congestive heart failure, the multitude of etiologies of congestive heart failure in this study was also a limitation. A larger sample size with a greater number of subjects in each etiologic subgroup would have been helpful in further analyzing the differences among subgroups of patients and the effect of etiology on physical activity levels and exercise capacity.

Another limitation of this study is the lack of a comparison group, such as age matched healthy sedentary individuals. Such a comparison group would have helped determine whether the results were indeed due to changes unique to the individuals with CHF or were a reflection of the sedentary lifestyle many ill people adopt.

One of the limitations of exercise testing is the use of symptom limited oxygen uptake rather than a true maximal oxygen uptake. As stated in chapter 2, maximal oxygen uptake is based largely upon the subjects' motivation as well as the ability of the tester to encourage the patient to continue. It is possible that the subjects' motivation could have limited exercise and maximal oxygen uptake. In addition, although most subjects had performed an exercise test before, most had never performed an exercise test with respiratory gas analysis, so unfamiliarity with the mask may have also limited exercise performance. However, an attempt to overcome this was made with the resting period prior to the exercise test so that individuals were given time to become accustomed to the facemask before its actual use. Ideally, more than 1 exercise test with respiratory gas analysis should have been performed.

In addition to the limitations of exercise testing, there were limitations with respect to physical activity levels. As mentioned earlier in this chapter, the Vitalog monitor has been used to determine exercise compliance as well as monitor the intensity of exercise performance based on heart rate and arm and leg motion. Therefore, the accuracy of the arm and leg motion especially during low level physical activity is questionable and requires further study.

In order to determine the reliability of the Vitalog monitor, 5 subjects wore the Vitalog monitor during exercise testing as well as during daily physical activity. It was hypothesized that during exercise testing heart rate and leg motion would be higher than during Vitalog monitored physical activity because exercise was of greater intensity. Heart rate was consistently higher during physical activity. However, there was a larger variability in leg motion. Four of 5 (80%) subjects had a decrease in leg motion during exercise testing. Because individuals rested both arms on the handrails during exercise testing, no change in arm motion was expected. In 3 (60%) individuals arm motion was greater during exercise testing than during Vitalog monitored physical activity. Arm motion may have been a result of vertical motion caused by walking on the treadmill. These findings suggest that there was a variability in instrument sensitivity which most probably was the primary threat to internal validity of this study and may be responsible for the apparent lack of significant findings.

Another question arises as to the time frame selected for analysis of physical activity. Because of difficulties with data analysis techniques for the Vitalog, the period selected for analysis was limited to the most strenuous physical activity performed by the individual while wearing the Vitalog monitor. This may have resulted in some lost data.

The last aspect of concern related to Vitalog monitored physical activity levels was whether the low levels of Vitalog monitored physical activity in this sample actually reflected a true level of physical activity or inactivity in this population. It is possible that what was observed in this study was the variability of daily physical activity (weekly or seasonal activity). Therefore, if another day or time of year were selected for Vitalog monitored physical activity measurements, the physical activity level for this sample may have been higher or perhaps lower. It would have also been helpful to examine physical activity levels over a greater period of time which would have allowed for averaging days to weeks.

## Implications for Nursing

### Clinical implications

The findings of this study may have an impact on clinical practice by enhancing awareness of the pitfalls of the functional assessment criteria currently used to assess physical activity levels of patients with congestive heart failure. Clinicians may need to supplement the information gathered with regards to performance of activities and symptoms experienced and realize that there may be a discordance between actual activity performance levels and maximal performance levels of physical activity. In addition, it is important for the clinician to bear in mind the possibility that the lack of symptoms may not only reflect physiologic compensation but psychosocial compensation as well.

Clinicians also may decide to encourage individuals to become more physically active, and provide guidelines to increase levels of physical activity. Other studies have demonstrated that exercise training does not increase mortality and enhances exercise capacity (Sullivan, Higginbotham, & Cobb 1988; Squires et al., 1987). It has also been demonstrated that interventions such as telephone coaching and education and follow-up enhanced self-efficacy expectation which corresponds to an improvement in general activity levels in patients post CABG surgery (Gortner & Jenkins, 1990). Therefore patient education may be a good mechanism to improve activity levels and this may be the key to matching exercise and functional capacity to actual levels of performance of daily physical activity.

## Future Research

Research in this area may include further reliability and validity studies with the Vitalog monitor or other monitoring systems. Other methods should be explored and developed, such as physical activity questionnaires which may be age or disease specific or the six minute walk test. The 6 minute walk test may be more useful than the exercise test in predicting physical activity levels and differentiating disease severity because it more closely resembles physical activity than does a maximal exercise test (Lipkin, Scriven, Crake, & Poole-Wilson, 1986).

The level of physical activity of age matched healthy sedentary individuals should be examined. Understanding the activity levels of age matched healthy sedentary subjects would provide comparison information and help to determine whether the level of physical activity observed in individuals with CHF is primarily due to the disease process itself or due to age or deconditioning. This idea also can be extended to other individuals with less debilitating cardiac disease, such as individuals with coronary artery disease.

Other studies may focus upon improving the level of physical activity individuals are capable of performing on a daily basis. Various exercise prescriptions or aspects of exercise prescriptions (such as type of exercise, intensity, duration, and frequency) should be examined to determine which are most effective in improving physical activity levels. Other strategies which would have an impact on self-efficacy beliefs could be developed that may assist the individual in improving physical activity levels. Gortner et al. (1988) have used coaching by telephone contact and education programs to improve efficacy beliefs and now have found that with coaching, self-efficacy expectations for walking and self-reported activity were improved (Gortner, & Jenkins, 1990). Perhaps this intervention can be applied to the CHF population to raise efficacy beliefs for general activity and walking.

Understanding how physical activity is limited or the barriers to physical activity of individuals with congestive heart failure may shed some light on why some individuals are more physically active than others and why physical activity levels are low. It can be speculated that particular physical activities may be eliminated while others are replaced or modified. How these changes are mediated might also prove to be a valuable research direction.

What was most striking regarding symptom appraisal was the lack of symptoms the majority of patients reported during Vitalog monitored physical activity. The lack of reported symptoms may reflect effective symptom management or may be due to the effect of different kinds of physical activity, such as arm versus leg movement in causing symptoms. If the apparent lack of symptoms reflects symptom management skills, it may be necessary to reexamine the use of the NYHA functional classification criteria because disease severity may not be assessed as it is currently thought. If some individuals are able to minimize their symptoms, understanding their coping strategies may assist others in managing their symptoms. By describing coping strategies these individuals use, effective strategies may be incorporated into exercise training programs to help improve physical activity levels.

Self-efficacy expectations as predictors and moderators of activity warrant further investigation. This study examined self-efficacy beliefs in relation to physical activity and exercise testing. It may be interesting to use exercise testing as a form of efficacy enhancement, as did Ewart et al. (1983), and examine its impact on subsequent physical activity levels of patients with congestive heart failure and attempting to quantitate the change, if any. Perhaps a key to improving the gap between exercise capacity and actual physical activity levels may lie in raising self-efficacy beliefs for exercise to be congruent with functional capacity.

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Appendix 1.

## UNIVERSITY OF CALIFORNIA, SAN FRANCISCO
## CONSENT TO BE A RESEARCH SUBJECT

### PURPOSE AND BACKGROUND:

I have been asked to participate in this study to learn more about activity levels of patients with congestive heart failure. This study is being conducted by Roberta K. Oka, R.N., M.N., a cardiac nursing doctoral student on the University of California, San Francisco Department of Physiological Nursing and Family Health Care, under the direction of Susan R. Gortner, Ph.D., R.N., (sponsor) and Michael Dae, M.D., Nancy Stotts, R.N., Ed.D., and William Haskell, Ph.D.(committee members).

### PROCEDURES

If I agree to be in this study, the following will happen:

(1) I will be answering questions about myself and my background. This interview will take approximately 10 minutes.

(2) I will wear a monitor with 2 electrodes one attached to my chest and the other my thigh, which will record motion and heart rate for 2 consecutive days and keeping a diary of my physical activities.

(3) I will be answering questions about which activities I feel confident I can perform at a particular time and also which activities I have actually performed within the past 24 hours. This interview will last approximately 10-15 minutes on the day of the exercise treadmill test.

(4) I will perform a treadmill exercise test and breathe into a mouthpiece so that measurements about my lungs can be made during the treadmill exercise test.

(4) While walking on the treadmill my heart rate and blood pressure will be monitored and I will be asked periodically how hard I feel I am working.

Participation in this study will take a total of 48 hours of wearing the monitor, and approximately 1-2 hours for treadmill exercise test, and activity checklist interview.

All study procedures will be at the Medical Center at the University of California, San Francisco.

## RISKS AND DISCOMFORTS

There are some possible risks or discomforts from being in this study:

(1) I may find completion of the checklists tiring and this might bring to the surface some things I might not care to think about. I may decline to answer the question or stop the interview at any time that I wish.

(2) There is also the possibility that while wearing the monitor, I may be uncomfortable.

(3) During the exercise test I may experience some shortness of breathe, leg or chest discomfort, or tiredness. If any of these symptoms are greater than normally expected during a treadmill exercise test, the exercise test will be stopped by the investigator, or I may stop the test at any time.

Confidentiality: My study records will be handled as confidentially as possible within the law. All my research records will be coded with a number and kept in a locked cabinet, only the study investigator will have access to my records. No individual identities will be used in any reports or publications resulting from this study.

## TREATMENT AND COMPENSATION FOR INJURY

If I am injured as a result of being in this study, treatment will be available. The costs of such treatment may be covered by the University of California depending on a number of factors. The University does not normally provide any other form of compensation for injury. For further information about this, I may call the office of the Committee on Human Research at (415) 476-1814.

## BENEFITS

The information gained from the treadmill exercise test may assist my physician in assessing my response to therapy. I may also enjoy the opportunity to think about the kinds of activities I am capable of performing. The information gained from this study will help in the understanding and possible treatment of patients with conditions similar to mine.

## ALTERNATIVES

If I chose not to participate in this study, my care will not be affected in any way.

## COSTS

I will not be charged for any of the study procedures or measurements. All costs will be paid by the investigator.

## REIMBURSEMENT

I will not be reimbursed for participating in this study.

## QUESTIONS

This study has been explained to me by Roberta Oka, R.N., M.N. and my questions were answered. If I have any other questions about the study, I may call Roberta Oka at (415) 664-4961, or her sponsor, Dr. Susan R. Gortner at (415) 476-4434.

## CONSENT

I have been given copies of this consent form and the Experimental Subject's Bill of rights to keep. PARTICIPATION IN RESEARCH IS VOLUNTARY. I have the right to decline to participate or to withdraw at any point in this study without jeopardy (to my medical care/employment/student status).

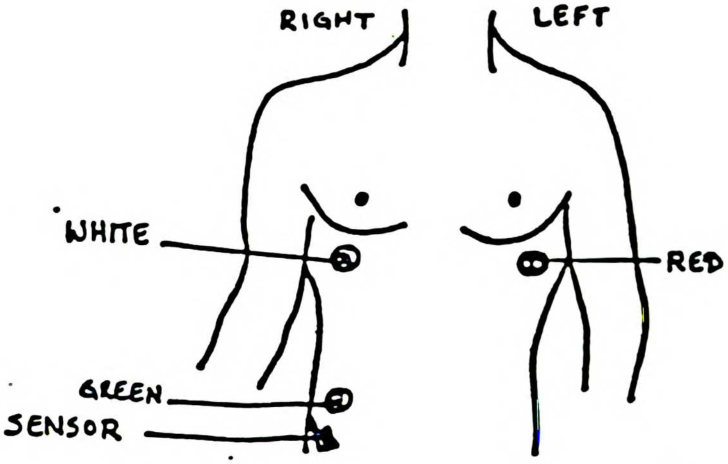
If I wish to participate, I should sign below.

Date

Subject's signature

Person Obtaining consent

Appendix 2.



Appendix 3.

## CHART REVIEW

Name: Date:

Pt. ID#: Birthdate/age: Gender:

Diagnosis:

**Medical History:**

length of illness (initial date):

complications:

other illness (diagnoses):

other symptoms/complaints:

surgeries:

angiography results:

echo results:

Previous treadmill results:

other pertinent studies:

EKG results:

**Medications (name/dose/frequency):**
side effects/ dosage changed?

Appendix 4.

|  | 4 | STAGE 5 | SPEED (MPH) 6 | GRADE (%) 7 | DURATION (MIN.) 8 9 (sec.) |
|---|---|---|---|---|---|
| PRE EXERCISE | (P) | (X) | (0) | (0) | (0) |
| EXERCISE | E | 0 | 1.0 | 0 | 3 |
|  | E | 1 | 1.5 | 0 | 3 |
|  | E | 2 | 2.0 | 3.5 | 3 |
|  | E | 3 | 2.0 | 7.0 | 3 |
|  | E | 4 | 2.0 | 10.5 | 3 |
|  | E | 5 | 3.0 | 7.5 | 3 |
|  | E | 6 | 3.0 | 10.0 | 3 |
|  | E | 7 | 3.0 | 12.5 | 3 |
|  | E | 8 | 3.0 | 15.0 | 3 |
|  | E | 9 | 3.4 | 14.0 | 3 |
|  | E | 10 | 3.4 | 16.0 | 3 |
| RECOVERY | (R) | (X) | (0) | (0) | 1 |
|  | (R) | (X) | (0) | (0) | 4 |
|  | (R) | (X) | (0) | (0) | 7 |
|  | (R) | (X) | (0) | (0) | 10 |

Appendix 5.

## BORG RATINGS OF PERCEIVED EXERTION SCALE

| | | |
|---|---|---|
| 0 | Nothing at all | |
| 1 | Very Weak | |
| 2 | Weak | (light) |
| 3 | Moderate | |
| 4 | Somewhat Strong | |
| 5 | Strong | (heavy) |
| 6 | | |
| 7 | Very Strong | |
| 8 | | |
| 9 | | |
| 10 | Very, Very strong | (almost max) |
| | Maximal | |

from: Borg, G.A.V., (1982). Psychological bases of perceived exertion. Medicine and Science and Sports and Exercise, 14(5), 380.

## Appendix 6.

### PHYSICAL ACTIVITY LOG

NAME:__________________________ DATE:__________________________

Got out of bed this morning______________________A.M. Went to bed this evening____________P.M.

| Time | Maximal exertion during this period | Physical Activity | Total Duration of this activity | Symptoms (check box) |
|---|---|---|---|---|
| | 0 1 2 3 4 5 6 7 8 9 10 | Type of Activity:<br>(Please specify):<br>____________ | Time began:_____<br>Time ended:_____<br>Total Duration (min's):______ | Shortness of breath( )<br>Fatigue ( )<br>Chest pain ( )<br>Sore muscles/joints( )<br>Other symptoms ( )<br>____________<br>No symptoms ( )<br>Please rate symptoms 0 - 10:________ |

Appendix 7.

# JENKINS SELF-EFFICACY EXPECTATIONS SCALES

## YOUR VIEWS

We are interested in learning how you view your confidence in your ability to carry out a group of activities at this point in time. Thus, there are no right or wrong answers to this questionnaire; it is your opinion that is important.

At the top of each of the pages that follow, you will be asked how confident you are right now of your ability to perform a behavior, such as walking various distances. To answer, consider the activities listed below the question and mark (either with a circle or an X) the number to the right that best matches your rating. The numbers range from 0 (no confidence) to 10 (total confidence). Please mark only one number for each activity.

For example, let us consider the behavior of reading. How confident are you right now that you can read:

a) a 3 page magazine article?
b) today's newspaper?
c) a 100 page book?
d) a 300 page book?

If you were totally confident you could read the magazine article and the newspaper, you would mark the 10 with an "X" after each of these activities. If you were less sure you could read a 100 page book, you would choose the number between 1 and 9 best indicating how sure you are and make an "X" through it. If you felt you definitely could not read a 300 page book, you would mark an "X" through the 0 to the right of that activity.

If an activity does not apply to you, do not mark a response. Go on to the next activity.

You will be asked about a broad range of activities. You should not use these questions as guidelines for your activities; rather you should follow the instructions your physician provides.

Thank you!

1985 LSJ rev. 6/87, 7/89

WALKING - How confident are you right now of your ability to walk:

| | No Confidence | | | | | | | | | | Total Confidence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| from your bed to the bathroom? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| around inside your home? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1/2 block? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1 block? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 2 blocks? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 3 blocks? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 4 blocks? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 5 blocks? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 6 blocks? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 8 blocks? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 10 blocks (1 mile)? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 15 blocks (1.5 miles)? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 20 blocks (2 miles)? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 30 blocks (3 miles)? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 40 blocks (4 miles)? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

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<u>GENERAL ACTIVITIES</u> - How confident are you <u>right now</u> of your ability to perform the following activities:

| | No Confidence | | | | | | | | | | Total Confidence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| brush teeth? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| take shower? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| shampoo hair? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| get dressed (regular clothing)? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| write letter/bill? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| empty small waste basket? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| make a sandwich? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| clear table? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| make your bed (not changing sheets)? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| eat at someone else's home? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| eat at a restaurant? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| go to a neighborhood store? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| go to a department store? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| go out for an evening (movie, concert, etc.)? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| go on a day trip (less than 100 miles)? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| go on a short overnight trip? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| return to <u>your</u> "normal" routine | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

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**HEALTH** - How confident are you right now of your ability to maintain your health by:

| | No Confidence | | | | | | | | | | Total Confidence |
|---|---|---|---|---|---|---|---|---|---|---|---|
| taking care of yourself? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| following your doctor's recommendations? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| exercising as instructed? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| following the dietary prescription recommended for you? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| taking your medication as instructed? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| keeping your medical appointments? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| participating in cardiac rehabilitation sessions? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| not smoking? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

## ACTIVITY SURVEY

A. Instructions: In the course of each day you carry out many activities. Please think about each of the following activities. Use a check mark to indicate whether or not you performed each one in the past 24 hours, or if the activity was not applicable to your situation.

WALKING

| | Yes | No | Not Applicable |
|---|---|---|---|
| from your bed to the bathroom? | | | |
| around inside your home? | | | |
| 1/2 block? | | | |
| 1 block? | | | |
| 2 blocks? | | | |
| 3 blocks? | | | |
| 4 blocks? | | | |
| 5 blocks? | | | |
| 6 blocks? | | | |
| 7 blocks? | | | |
| 8 blocks? | | | |
| 10 blocks (1 mile)? | | | |
| 15 blocks (1.5 miles)? | | | |
| 20 blocks (2 miles)? | | | |
| 30 blocks (3 miles)? | | | |
| 40 blocks (4 miles)? | | | |

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GENERAL ACTIVITIES:

| | Yes | No | Not Applicable |
|---|---|---|---|
| brush teeth? | | | |
| take shower? | | | |
| shampoo hair? | | | |
| get dressed (regular clothing)? | | | |
| write letter/bill? | | | |
| empty small wastebasket? | | | |
| make a sandwich? | | | |
| clear table? | | | |
| make your bed (not changing sheets)? | | | |
| eat at someone else's home? | | | |
| eat at a restaurant? | | | |
| go to a neighborhood store? | | | |
| go to a department store? | | | |
| go out for an evening (movie, concert, etc.) | | | |
| go on a day trip (less than 100 miles)? | | | |
| go on a short overnight trip? | | | |
| return to <u>your</u> "normal" routine? | | | |

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<u>HEALTH</u>: For each of the following activities, mark the number to the right which best indicates the extent to which you are <u>maintaining your health by</u>:

| | Never | | | | | | | | | | Always |
|---|---|---|---|---|---|---|---|---|---|---|---|
| taking care of yourself? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| following your doctor's recommendations? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| exercising as instructed? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| following the dietary prescription recommended for you? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| taking your medication as instructed? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| keeping your medical appointments? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| participating in cardiac rehabilitation sessions? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| not smoking? | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

Appendix 8. Relationship between New York Heart Association functional classification and exercise capacity

Heart rate at maximal exercise

| Variable | N | Mean | SD |
|---|---|---|---|
| Class I | 9 | 125.78 | 26.24 |
| Class II | 17 | 123.97 | 20.97 |
| Class III | 13 | 136.54 | 18.33 |

Fmax for testing homogeneity of between subjects variances: 2.04

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between subjects | | | | |
| NYHAFC | 2 | 629.93 | 1.368 | ns |
| Error | 44 | 460.44 | | |

Maximum oxygen uptake

| Variable | N | Mean | SD |
|---|---|---|---|
| Class I | 11 | 19.36 | 7.09 |
| Class II | 21 | 14.62 | 3.81 |
| Class III | 15 | 17.86 | 8.15 |

Fmax for testing homogeneity of between subjects variances: 4.58

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between subjects | | | | |
| NYHAFC | 2 | 94.79 | 2.413 | ns |
| Error | 44 | 39.15 | | |

Maximal Metabolic Equivalents

| Variable | N | Mean | SD |
|---|---|---|---|
| Class I | 11 | 5.55 | 2.50 |
| Class II | 21 | 3.90 | 1.45 |
| Class III | 15 | 4.40 | 2.47 |

Fmax for testing homogeneity of between subjects variances: 3.00

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between subjects | | | | |
| NYHAFC | 2 | 9.74 | 2.254 | ns |
| Error | 44 | 4.32 | | |

Exercise duration

| Variable | N | Mean | SD |
|---|---|---|---|
| Class I | 11 | 16.80 | 7.61 |
| Class II | 21 | 12.16 | 4.17 |
| Class III | 15 | 13.13 | 7.35 |

Fmax for testing homogeneity of between subjects variances: 3.33

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between subjects | | | | |
| NYHAFC | 2 | 79.68 | 2.081 ns | |
| Error | 44 | 38.29 | | |

Percent of maximal oxygen uptake at which anaerobic threshold occurs

| Variable | N | Mean | SD |
|---|---|---|---|
| Class I | 8 | .756 | .0952 |
| Class II | 16 | .796 | .0834 |
| Class III | 11 | .682 | .0708 |

Fmax for testing homogeneity of between subjects variances: 1.81

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between subjects | | | | |
| NYHAFC | 2 | .0423 | 6.213 | .005 |
| Error | 32 | .0068 | | |

---

Post-hoc tests for factor New York Heart Association functional classification

| Level | Mean |
|---|---|
| Class I | .755 |
| Class II | .796 |
| Class III | .682 |

Comparison Scheffe'

Class I < Class II

Class I > Class III

Class II > Class III p=.005

Oxygen uptake at which anaerobic threshold occurs

| Variable | N | Mean | SD |
|---|---|---|---|
| Class I | 8 | 16.13 | 5.00 |
| Class II | 16 | 11.34 | 1.38 |
| Class III | 11 | 13.25 | 4.71 |

Fmax for testing homogeneity of betweeen subjects variances: 13.22

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between subjects | | | | |
| NYHAFC | 2 | 61.32 | 4.62 | .02 |
| Error | 32 | 13.28 | | |

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Post-hoc tests for factor New York Heart Association functional classification

| Level | Mean |
|---|---|
| Class I | 16.13 |
| Class II | 11.34 |
| Class III | 13.25 |

Comparison Scheffe'

Class I > Class II p=.02

Class I > Class III

Class II < Class III

Respiratory Quotient

| Variables | N | Mean | SD |
|---|---|---|---|
| Class I | 11 | 1.01 | .1180 |
| Class II | 21 | 1.02 | .0839 |
| Class III | 15 | 1.08 | .1505 |

Fmax for testing homogeneity of between subjects variances: 3.21

| Source | df | MSS | F | p |
|---|---|---|---|---|
| Between subjects | | | | |
| NYHAFC | 2 | .0190 | 1.397 | ns |
| Error | 44 | .0136 | | |

Appendix 9. Difference between activity levels based upon New York Heart Association Functional Classification

Heart Rate during activity

| Variable | N | Mean | SD |
|---|---|---|---|
| Class I | 9 | 73.22 | 11.72 |
| Class II | 17 | 74.12 | 8.21 |
| Class III | 13 | 83.23 | 16.80 |

Fmax test for homogeneity of between subjects variances: 1.52

| Source | df | MSS | F | p |
|---|---|---|---|---|
| NYHAFC | 2 | 387.13 | 2.50 | ns |
| Error | 36 | 154.60 | | |

Arm motion during activity

| Variable | N | Mean | SD |
|---|---|---|---|
| Class I | 11 | 23.16 | 19.58 |
| Class II | 20 | 33.91 | 28.97 |
| Class III | 15 | 21.88 | 13.08 |

Fmax for testing homogeneity of between subjects variances: 4.90

| Source | df | MSS | F | p |
|---|---|---|---|---|
| NYHAFC | 2 | 751.47 | 1.457 | ns |
| Error | 43 | 515.76 | | |

Leg motion during activity

| Variable | N | Mean | SD |
|---|---|---|---|
| Class I | 10 | 18.73 | 23.32 |
| Class II | 21 | 8.24 | 9.65 |
| Class III | 15 | 6.86 | 4.71 |

Fmax for testing homogeneity of between subjects variances: 24.50

| Source | df | MSS | F | p |
|---|---|---|---|---|
| NYHAFC | 2 | 487.74 | 2.97 | ns |
| Error | 44 | 164.34 | | |